2020

Evaluating the Polishing of Skid Aggregates in Asphalt using the British Pendulum Tester

Allison Nicole Givens

West Virginia University, angivens@mix.wvu.edu

Follow this and additional works at: <https://researchrepository.wvu.edu/etd>

Part of the [Civil Engineering Commons](#), and the [Transportation Engineering Commons](#)

Recommended Citation

Givens, Allison Nicole, "Evaluating the Polishing of Skid Aggregates in Asphalt using the British Pendulum Tester" (2020). *Graduate Theses, Dissertations, and Problem Reports*. 7531.

<https://researchrepository.wvu.edu/etd/7531>

This Thesis is protected by copyright and/or related rights. It has been brought to you by the The Research Repository @ WVU with permission from the rights-holder(s). You are free to use this Thesis in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you must obtain permission from the rights-holder(s) directly, unless additional rights are indicated by a Creative Commons license in the record and/ or on the work itself. This Thesis has been accepted for inclusion in WVU Graduate Theses, Dissertations, and Problem Reports collection by an authorized administrator of The Research Repository @ WVU. For more information, please contact researchrepository@mail.wvu.edu.

Evaluating the Polishing of Skid Aggregates in Asphalt using the British Pendulum Tester

Allison Givens

Thesis submitted
to the Benjamin Statler College of Engineering and Mineral Resources
at West Virginia University

in partial fulfillment of the requirements for the degree of

Master of Science in
Civil and Environmental Engineering

John P. Zaniwski, Ph.D., P.E., Chair
John Quaranta, Ph.D., P.E.
Karl Barth, Ph.D.

Wadsworth Department of Civil and Environmental Engineering

Morgantown, West Virginia
2020

Keywords: British Pendulum Tester, Polishing, Skid Resistant Aggregates
Copyright 2020 Allison Givens

ABSTRACT

Evaluating the Polishing of Skid Aggregates in Asphalt using the British Pendulum Tester

Allison Givens

To ensure the pavements in West Virginia have adequate skid resistance the Division of Highways evaluates and approves skid resistant aggregate sources for all wearing courses on roads with an ADT of 3,000 or greater. Unfortunately, the supply of skid aggregates in West Virginia is depleting quickly. To find a potential alternative to using skid resistant aggregates, laboratory polishing of asphalt samples was performed using a Circular Track Polishing Machine, and friction was tested using a British Pendulum Tester. The experiment was designed to investigate how a specific aggregate type provides skid resistance to a hot asphalt mixture.

The objective of this research was to evaluate the repeatability of a newly developed polishing procedure, establish a difference between skid and non-skid mixes, and investigate the effect of the amount of skid resistant aggregate on the friction an asphalt mixture. Four mixes with varying amounts of skid aggregate were evaluated. The four mixes were compacted, polished, and tested following a recommended protocol established in an earlier phase of the research. The procedure was then used to determine the friction values of the mixes. Insoluble residue tests were then performed on the skid specific mixes to verify the skid resistant aggregate contents.

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. John Zaniwski, for providing with the opportunity to further my education and for his utmost guidance and assistance in completing this research. I would also like to thank my committee members, Dr. John Quaranta and Dr. Karl Barth, for each of their contributions and support throughout this research.

I would also like to thank the West Virginia Division of Highways (WVDOH) for providing this opportunity and the resources necessary to complete it. I would like to thank participating contractors for providing materials needed to for this research. I am extremely grateful to Chadley Miller for the tremendous amount of help in developing and performing this experiment.

Next, I want to thank my fellow graduate students for all of their support and assistance throughout my research. Lastly, I want to thank my family and friends for their endless support throughout my graduate education and this project.

Table of Contents

List of Figures	vi
List of Tables	viii
List of Abbreviations	x
Chapter 1: Introduction	1
Background	1
Problem Statement	1
Objectives.....	2
Scope and Limitations.....	2
Report Outline	2
Chapter 2: Literature Review.....	3
Skid Resistance	3
Polishing.....	4
Friction Measurements.....	7
Insoluble Residue Test	7
Chapter 3: Methodology	10
Sample Preparation Method	10
Polishing Method	10
Validate Experiment Repeatability	14
Skid Resistant Asphalt Experiment.....	15
Insoluble Residue Test	16
Chapter 4: Results and Discussion.....	18
Comparison for Repeatability	18
Skid Resistant Asphalt Results.....	21
Chapter 5: Conclusions and Recommendations	30

Conclusions	30
Recommendations	31
References	32
List of Test Methods Used	33
Appendix A: Mix Design	34
Job Mix Formulas	34
Batch Sheets	39
Appendix B: Replicate Study Data	43
Appendix C: Skid Resistant Asphalt Experiment Data	54
Appendix D: Insoluble Residue Data	59
Asphalt Burn-off	59
Insoluble Residue per WVDOH Method	69
Insoluble Residue per Material Passing WVDOH Method	72
Insoluble Residue per Total Blend of Sample	75

List of Figures

Figure 1. Illustration of Aggregate Microtexture and Macrotexture (Mataei et al., 2016)	4
Figure 2. North Carolina State University Circular Track Polishing Machine (ASTM E660)	5
Figure 3: British Pendulum Tester	12
Figure 4: WVDOH Polishing Machine	14
Figure 5: Comparison Chart for Estimation of Percentage Composition (WVDOH MP 703.00.29)	17
Figure 6: Average BPN After 48,000 Wheel Passes at 4% VTM with High Toe	18
Figure 7: Average BPN After 48,000 Wheel Passes at 8% VTM with High Toe	19
Figure 8: Average BPN After 48,000 Wheel Passes at 4% VTM with Low Toe	19
Figure 9: Average BPN After 48,000 Wheel Passes at 8% VTM with Low Toe	20
Figure 10: Average BPN Comparison for Original vs. Replicate	21
Figure 11: Progression of polishing	22
Figure 12: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with High Toe	23
Figure 13: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with Low Toe	23
Figure 14: Average BPN per specimen for Low Toe and High Toe after 80,000 Wheel Passes	24
Figure 15: Skid Aggregate Content vs. Average BPN	26
Figure 16: Skid Aggregate Content vs. +200 Quartz Insoluble Residue	27
Figure 17: Microscopic view of Insoluble Residue	29
Figure 18: Job Mix Formula for J. F. Allen Co. – 12.5 mm SKID – RAP	34
Figure 19: Job Mix Formula for West Virginia Paving, Inc. – Wearing 1 – RAP	35
Figure 20: Job Mix Formula for Greer – Wearing 1 Heavy	36
Figure 21: Job Mix Formula for West Virginia Paving, Inc. – 12.5 mm Skid – RAP	37
Figure 22: Job Mix Formula for J. F. Allen Co. – 9.5 mm SKID - Per Design Mixture	38
Figure 23: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - No Skid Mixture	39
Figure 24: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - Per Design Mixture	40
Figure 25: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - Opposite Skid Mixture	41
Figure 26: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - All Skid Mixture	42
Figure 27: Binder Burn-off Tickets for All Skid and Opposite Skid	59
Figure 28: Binder burn-off tickets for Per Design and No Skid	60
Figure 29: Gradation of Aggregates from binder burn-off for All Skid Sample #1	61

Figure 30: Gradation of Aggregates from binder burn-off for All Skid Sample #2	62
Figure 31: Gradation of Aggregates from binder burn-off for Opposite Skid Sample #1	63
Figure 32: Gradation of Aggregates from binder burn-off for Opposite Skid Sample #2	64
Figure 33: Gradation of Aggregates from binder burn-off for Per Design Sample #1	65
Figure 34: Gradation of Aggregates from binder burn-off for Per Design Sample #2	66
Figure 35: Gradation of Aggregates from binder burn-off for No Skid Sample #1	67
Figure 36: Gradation of Aggregates from binder burn-off for No Skid Sample #2	68

List of Tables

Table 1: Specification of Components in CTPM according to ASTM E660	6
Table 2: Modifications of WVDOH Polishing Equipment and Procedure to ASTM E660 (Hoyer, 2020)	11
Table 3: Combinations of mixtures used in testing.....	15
Table 4: Skid resistant aggregate distribution in mixtures.....	16
Table 5: Statistical comparison for original vs. replicate results	20
Table 6: BPN Average and Standard Deviation	25
Table 7: t-Test results for average BPN of specimen at 80,000 wheel passes.....	26
Table 8: Summary of average Insoluble Residue results per sample for each method	27
Table 9: Insoluble Residue (% Quartz) vs. Average BPN.....	28
Table 10: Ranking of IR and BPN.....	28
Table 11: BPN data for Series 1 specimen	43
Table 12: BPN data for Series 2 specimen	45
Table 13: BPN data for Series 3 specimen	47
Table 14: BPN data for Series 4 specimen	49
Table 15: Data for Original and Replicate Statistical Comparison.....	51
Table 16: Comparison of Average BPN After 48,000 Wheel Passes at 4% VTM, High Toe.....	52
Table 17: Comparison of Average BPN After 48,000 Wheel Passes at 8% VTM, High Toe.....	52
Table 18: Comparison of Average BPN After 48,000 Wheel Passes at 4% VTM, Low Toe	53
Table 19: Comparison of Average BPN After 48,000 Wheel Passes at 8% VTM, Low Toe	53
Table 20: BPN data for specimen using High Toe	54
Table 21: BPN data for specimen using Low Toe	56
Table 22: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with High Toe	58
Table 23: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with Low Toe	58
Table 24: Skid Aggregate Content vs Average BPN.....	58
Table 25: IR Data for WVDOH Method All Skid Sample #1	69
Table 26: IR Data for WVDOH Method All Skid Sample #2	69
Table 27: IR Data for WVDOH Method Opposite Skid Sample #1.....	69
Table 28: IR Data for WVDOH Method Opposite Skid Sample #2.....	70

Table 29: IR Data for WVDOH Method Per Design Sample #1	70
Table 30: IR Data for WVDOH Method Per Design Sample #2	70
Table 31: IR Data for WVDOH Method No Skid Sample #1	71
Table 32: IR Data for WVDOH Method No Skid Sample #2	71
Table 33: IR Data for Material Passing WVDOH Method All Skid Sample #1	72
Table 34: IR Data for Material Passing WVDOH Method All Skid Sample #2	72
Table 35: IR Data for Material Passing WVDOH Method Opposite Skid Sample #1	72
Table 36: IR Data for Material Passing WVDOH Method Opposite Skid Sample #2	73
Table 37: IR Data for Material Passing WVDOH Method Per Design Sample #1	73
Table 38: IR Data for Material Passing WVDOH Method Per Design Sample #2	73
Table 39: IR Data for Material Passing WVDOH Method No Skid Sample #1	74
Table 40: IR Data for Material Passing WVDOH Method No Skid Sample #2	74
Table 41: IR Data for Total Blend All Skid Sample #1	75
Table 42: IR Data for Total Blend All Skid Sample #2	75
Table 43: IR Data for Total Blend Opposite Skid Sample #1	75
Table 44: IR Data for Total Blend Opposite Skid Sample #2	76
Table 45: IR Data for Total Blend Per Design Sample #1	76
Table 46: IR Data for Total Blend Per Design Sample #2	76
Table 47: IR Data for Total Blend No Skid Sample #1	77
Table 48: IR Data for Total Blend No Skid Sample #2	77

List of Abbreviations

AASHTO = American Association of State Highway and Transportation Officials

ASTM = American Society for Testing and Materials

BPN = British Pendulum Number

BPT = British Pendulum Tester

CTPM = Circular Track Polishing Machine

FHWA = Federal Highway Administration

G_{mb} = Bulk Specific Gravity

G_{mm} = Specific Gravity of Mix

HMA = Hot Mix Asphalt

IR = Insoluble Residue

JFA = J.F. Allen Company

NCSU = North Carolina State University

RAP = Reclaimed Asphalt Pavement

SGC = Superpave Gyratory Compactor

SR = Skid-RAP Asphalt Mixture

VTM = Voids in the Total Mixture

W1 = Wearing 1 Asphalt Mixture Course

WV = West Virginia

WVDOH = West Virginia Division of Highways

WVP = West Virginia Paving, Inc.

WVU = West Virginia University

Chapter 1: Introduction

Background

Safety characteristics for a roadway are of the highest priority when designing a roadway. On average, there are about 5,891,000 car crashes each year, and 21% of these crashes are weather related (FHWA, 2020). Weather events can greatly affect the roadways, and safety is one of those factors. Skid resistance is a large contributor to safety of the roadways. Skid resistance can be achieved in many ways; a couple ways include: microsurfacing treatments or proper surface mix designs with specific aggregate characteristics. Polish resistant aggregates, or skid resistant aggregates, are a large contender in skid resistance mix designs (FHWA, 2005).

The polish resistant aggregates are used in the surface courses to increase the skid resistance by reducing the polishing effect from vehicles. Skid resistant aggregates utilized in hot mix asphalt (HMA) mixtures is in great demand, but the supply of the skid resistant aggregates is low. Doing research on the effects of polishing skid resistant aggregates in a hot mix asphalt (HMA) pavements compared to the effects of polishing non-skid resistant aggregates in pavements will allow a better understanding of the surface characteristics of the respective asphalt pavements. The data found could provide insight on the characteristics the chosen aggregates provide to the asphalt pavement when designing new mixture designs.

Problem Statement

This research was completed to identify the skid resistance of asphalt mixes using the British Pendulum Tester (BPT). The research was performed to find a correlation between the amount of skid resistant aggregates used in the mixture to the amount of skid resistance of the asphalt pavement with the newly developed method by a previous experimenter and West Virginia University (WVU). These findings can provide insight for the WVDOH and contractors on the asphalt pavements' skid resistance performance.

Objectives

There were three main objectives for this research: 1) evaluate test method repeatability, 2) polish and test the four mixes, and 3) verify the skid resistant aggregate content of each mixture design.

Achieving these objectives ensures that the procedure for finding the friction results can be used for future experiments. The verified data could provide insight to alternative mix designs that provide adequate skid resistance without the use of limited skid resistant aggregates.

Scope and Limitations

The polishing and friction measurement equipment used in this research were provided by the WVDOH. There was no opportunity to evaluate and select other equipment. The HMA for the replicate study were provided by three contractors. The experiment with the varying amounts of skid aggregate were from a single contractor. Field samples were not available for testing. All tests were performed on laboratory compacted samples.

Report Outline

The report has five chapters. These chapters include: Introduction, literature review, methodology, results and discussion, and conclusion and recommendations. The first chapter is the introduction. The second chapter is the literature review. Chapter three covers the methodology throughout the project. Chapter four presents and discusses the results found during testing. The fifth chapter explains the conclusions and recommendations for future work. Appendices are provided for supplemental data.

Chapter 2: Literature Review

Creating a device to accurately simulate the polishing effect in the field is vital to laboratory testing hot mix asphalt (HMA) polishing. Testing methods proceeding polishing includes a British Pendulum Tester (BPT), as described in AASHTO and ASTM standards. A Circular Track Polishing Machine CTPM and a British Pendulum Tester (BPT) were delivered to WVU to perform such tests. These two devices will allow for the evaluation of skid resistance performance of the HMA mixtures designed for this experiment. The following reviews:

- Summary of skid resistance in asphalt pavements
- Polishing HMA using an ASTM E660 device
- Friction measurements with the British Pendulum Tester
- Insoluble Residue Test

Skid Resistance

Skid resistance is an essential characteristic for roadways. Skid resistance serves as a safety measure when designing a pavement. Skid resistance is defined as the force between the tire and the roadway that prevents the tire from sliding. The skid resistance depends on the tire and pavement characteristics. The pavement characteristics affecting skid resistance are macrotexture and microtexture (Liang, 2003).

Macrotexture is the roughness that can be seen with the eye. The aggregate size and the voids between the aggregates are contributors to macrotexture. Macrotexture is described as voids ranging from 0.5 mm up to 50 mm (Henry, 2000). Macrotexture affects friction on wet pavement at higher speeds, where the voids are large enough to disperse water from the pavement surface (FHWA, 2015).

Microtexture can be described as the surface texture of the aggregates. Microtexture affects the skid resistance at lower speeds (Henry, 2000). Microtexture is described as variations in the surface texture in the range of 0.001 mm – 0.5 mm (Henry, 2000).

Figure 1 illustrates the difference between microtexture and macrotexture. Microtexture can be effected by the type of aggregates used in the asphalt mixture. When using an aggregates that is not easily polished, or skid resistant, it can increase the longevity of microtexture.

Figure 1. *Illustration of Aggregate Microtexture and Macrotexture (Mataei et al., 2016)*

Some aggregates that will increase the friction of the surface are sandstone, quartz, limestone, and granite. The WVDOH MP 402.02.20 describes how skid resistant aggregates are tested to be qualified skid aggregates for West Virginia. The percentage of carbonate particles is evaluated in order to determine the percentage of material that is not polish susceptible. The WVDOH MP 703.00.29 is an additional test performed to determine the amount of insoluble residue in the carbonate aggregates. The material studied in WVDOH MP 703.00.29 test is quartz, and the final percentage of insoluble residue is measured from the total amount of quartz passing through the No. 30 sieve and retained on the No. 200 sieve.

Polishing

The skid resistance of a pavement decreases due to the polishing from vehicle tires over a period of time or cycles. Polishing devices are used to simulate the friction low of pavement materials in the laboratory. There are many types polishing devices, however, the Circular Track Polishing Machine (CTPM) developed at North Carolina State University (NCSU), which was the basis for the CTPM described in ASTM E660, Figure 2, was selected by the WVDOH for use in this research.

Figure 2. *North Carolina State University Circular Track Polishing Machine (ASTM E660)*

The main components of the CTPM are described in Table 1 (ASTM E660). The prescribed polishing and testing sequence is:

1. The initial friction is measured of twelve samples.
2. Place samples flush in the mounting plates or clamping ring.
3. Lower the wheels onto the samples
4. Run the polisher at 30 rpm for the desired revolutions.
5. Stop polishing after 1 hour and measure the friction of each sample.
6. Repeat friction measurements in 2 hour intervals. The intervals are performed until the terminal polishing is achieved, at approximately 8 hours (ASTM E660).

Table 1: Specification of Components in CTPM according to ASTM E660

Component	Specification Elements	Purpose
Wheel Assembly	Four equally spaced tires	
	Individually suspended from central drive shaft	
	Adjustable wheel toe	Alternating toe-in 4° and toe-out 2°
	Free rolling wheel	
	Nylon smooth no-pattern tread tires, 2-ply rating	
	Tire size of 11 in×6 in×5 in, tire pressure 20 psi	
	Horizontal fender above each wheel	Hold extra weight for increased wheel loading
Drive Mechanism	Electric motor	Rotate central drive shaft
	Allowable 30±2 rpm	
Circular Track	36 inch diameter, from center of wheel paths	
	Adequate spacing for 12 equally spaced specimen holders	
Specimen Holder	Bottom metal mounting plates	Base for trapezoidal and circular specimens
	Three adjustable, lockable bolts	Mounting and leveling individual specimens on the metal plates
	Top metal plate, with evenly spaced 6 inch circular cutouts in wheel path	Track running surface for circular specimens
	Clamping rings	Securing sample when epoxy glue is not used
Electrical System	Comprised of three circuits	
	Motor circuit with slow-blow fuse	Protect motor in accidents
	Subtracting predetermined revolution counter	Control motor
Safety Guards	Interlocked into motor circuit	Machine will not operate if safety guards are not in place

Friction Measurements

There are several methods for evaluating pavement texture and friction in a laboratory. The British Pendulum Tester (BPT) was selected by the WVDOH for use on this project. The BPT is a widely accepted device; its use is covered by ASTM E303 and AASHTO T 278. The BPT measures the friction as a rubber pad slides across the sample surface. Since the pendulum moves at a speed equivalent to 10 km/h or 6 mph (Henry, 2000), the friction is a measure of microtexture (AASHTO T 278).

The BPT has to be set up according to specifications when testing a specimen. The base of the BPT has 3 adjustable legs that are to be used for leveling the machine before testing. The pendulum has to be raised or lowered to the height for the rubber slider to have a contact path of $4 \frac{15}{16} \pm \frac{1}{16}$ in. on the specimen. Once this is achieved, the surface of the specimen being tested must be thoroughly cleaned, and the surface must be sufficiently wetted (ASTM E303). The specimen is to be wetted, or spray with water, in order to mimic environmental conditions. Skid resistance is lower when the surface is wet than when the pavement is dry (Ahmad, 2015).

At the start of the test, the pendulum is locked in position and then released, allowing for the rubber slider to drag across the wetted surface. A drag pointer, connected to the pendulum, indicates the highest point the pendulum reaches. The BPT quantifies the friction value as the British Pendulum Number (BPN). The BPN ranges from 0 to 140, 0 equaling no friction. The BPN is a measure of the amount of energy lost when the slider is propelled over the sample (Lu, 2006). This procedure is performed 5 times for specimens with flat surfaces. The results of the first swing is not recorded; the average of the results for the remaining 4 swings is the BPN.

Insoluble Residue Test

The skid resistance of the pavements also depends on the amount of insoluble residue in the aggregates being used (O'Brien and Haddock, 2009). "In the insoluble residue test (ASTM D3042), the aggregate is dissolved in dilute hydrochloric acid, and the remaining insoluble portion is usually made up of quartz (silica), feldspar (clays), or other insoluble minerals" (O'Brien and Haddock, 2009). The purpose of this test is to identify the properties of the aggregates by removing the carbonate material with hydrochloric acid and relate the properties, such as hardness, to the skid resistance. Many state DOTs have a modified version of the

insoluble residue test (Jayawickrama et al. 1998). The insoluble residue test is used in West Virginia to determine the amount of aggregate that is not able to be polished easily and allow for greater skid resistance, such as quartz. The MP 402.02.20 test allows for WVDOH to determine if the aggregate type in questioning is considered as a skid resistant aggregate. The MP 703.00.29 allows for the WVDOH to determine the amount of insoluble material, specifically quartz, left from the blend of carbonate aggregates.

The type of aggregate chosen for the mix design is crucial for the frictional properties. As mentioned previously, the texture of the pavements greatly affects the skid resistance. The texture includes the microtexture and macrotexture, with microtexture being considered more influential to skid resistance. When the pavement is polished by vehicle tires, there is a decrease the skid resistance (O'Brien and Haddock, 2009). Since the skid resistance is measured by the force between tire and the pavement, when there is water on the road, this can disrupt the friction force between the two surfaces. This is especially worse for pavements that are polished; the pavement has no microtexture to remove the thin water film left from the larger movement of water due to macrotexture (O'Brien and Haddock, 2009). Choosing aggregates for the mix design that have a specific hardness is very important when trying to maintain adequate microtexture. Aggregates with a higher hardness have a "longer rate of polishing" which increases the lifespan of available microtexture (O'Brien and Haddock, 2009). It is important to have the higher hardness aggregates complemented with the softer mineral to keep the minerals well bonded (Liang, 2003). This will produce a design that will resist polishing and wearing effectively. Dahir and Mullen (1971) concluded that having a mixture of harder and softer minerals in the aggregates produced higher skid resistance than mixes having aggregates with mostly harder minerals.

When using softer minerals such as limestone or dolomite in the blend of aggregates, it is important to determine the content of insoluble residue since the carbonate aggregate is easily polished (O'Brien and Haddock, 2009). The first reports of insoluble residue correlating to skid resistance recommended that of the aggregates retained on the No. 200 sieve, at least ten percent of the aggregate blends should consist of insoluble residue. There are other recommendations of having insoluble residue contents of fifteen and twenty percent, but there is no evidence on which percentage performs best (O'Brien and Haddock, 2009). Additional studies recommend having at least 25 percent of insoluble residue of the total blend to maintain skid resistance

(Masad et al. 2009). Others have reported of having 50 to 70 percent of the harder materials in the skid aggregates themselves to be sufficient (Dahir and Mullen, 1971).

The size of the skid resistant particle is also an important characteristic. While the first reports of insoluble residue include the materials retained on a No. 200 sieve, a study by Masad et al. (2009) suggests limiting the particle size to being retained on a No. 50 sieve for being counted in the contributing skid resistance. O'Brien and Haddock (2009) studied that having insoluble residue passing the No. 200 sieve increased skid resistance, speculating "that the tiny clay particles that make up the portion smaller than the #200 sieve break out of the carbonate matrix creating an irregular surface and providing the needed micro-texture for good skid resistance." Other studies have shown that having insoluble residue sand increases the skid resistance (Dahir and Mullen, 1971).

Chapter 3: Methodology

The research methodology included five steps: sample preparation, polishing methodology, replicate experiment, skid resistant mixes experiment, and evaluation of insoluble residue test of skid resistant mixes.

Sample Preparation Method

Sample preparation began with determining the maximum specific gravity (G_{mm}) of the asphalt mixtures. Following AASHTO T 209, 1500 g of each asphalt mixture was heated in the oven in separate pans at 105°C. The HMA Particles are separated by hand and left to cool to room temperature. The separated particles were placed into the pre-weighed vacuum container to determine the mass of the sample being used and perform mechanical agitation of the sample. The remaining weights were taken, and the G_{mm} was calculated.

The mass of the mixture needed for each sample was then determined and samples were compacted accordingly to AASHTO R 83-17. Specimen with dimensions of 90 mm tall and 150 mm diameter were compacted with the Superpave Gyratory Compactor (SGC). To conserve the amount of asphalt mixture used and to fit the samples into the polishing machine, the height of 90 mm was preferred over the height in AASHTO R 83-17. Asphalt mixture was heated to 100°C, quartered, and then heated to the mixture compaction temperature. The mixture is then placed into the compaction mold, compacted, and then left to cool to room temperature overnight. The sample is numbered, and the top and bottom are labeled.

The voids in the total mix (VTM) or air voids, is measured to verify the desired VTM for the experiment. This is done accordingly to Method A in AASHTO T 166-16. To prepare the specimen for this test, it is placed into the CoreDry device to remove any moisture inside the sample voids. The bulk specific gravity (G_{mb}) is found, and the VTM is calculated. The specimen is ready for polishing once the desired VTM is verified.

Polishing Method

The WVDOH-CTPM developed by the following ASTM E660 is shown in Figure 4. There were minor modifications in the polishing machine developed by the WVDOH and the

procedure recommended by Hoyer (2020). The differences from the ASTM E660 specifications are listed in Table 2.

Table 2: Modifications of WVDOH Polishing Equipment and Procedure to ASTM E660 (Hoyer, 2020)

		ASTM E660-90	WVDOH
Equipment	Tires	Pressure = 20psi	Pressure = 30psi
		Nylon smooth no- pattern; 2-ply rating	Hoosier R80
	Wheels	Option for studded wheels	No studded wheels
Procedure	Specimens	Laboratory = 6" diameter, no height specified; field core = 6" diameter, 38mm height (bituminous)	Laboratory = 6" diameter, 90mm height; 6" diameter field core specimens ≈90mm height if possible (bituminous)
		Option for concrete specimens	No concrete specimens
	Abrasive	No abrasive	Silicon Carbide Powder
	Toe Angles	4° toe in 2° toe out only	4° toe in 2° toe out; 8° toe in 4° toe out
	Tire Hardness	No monitoring	Monitored with durometer every 4,000/6,000 revolutions (16,000/24,000 wheel passes)
	Friction Evaluation	NCSU Variable Speed Friction Tester recommended	British Pendulum Tester (BPT)
		Measurements recorded at 0, 7200, 14400, 28000, 43200, and 57,600 wheel passes	Measurements recorded at 0, 8000, 16000, 32000, and 48000 wheel passes
	Sufficient Polishing	57,600 wheel passes (7,200 wheel passes per hour for 8hr)	48,000 wheel passes

Before polishing the initial friction if each sample was measured with the BPT, using the following steps:

1. Secure specimen in BPT fixing jig.
2. Adjust pendulum height for slider contact path of 5 inches.

3. Lock pendulum in place.
4. With a spray bottle, do 30 sprays of water onto specimen surface.
5. Release pendulum.
6. Read BPN from the drag pointer.
7. Immediately, relock pendulum back into place.
8. Apply 5 sprays of water to the surface.
9. Release pendulum.
10. Read and record BPN from that drag pointer.
11. Repeat steps 7-10 a total of four times.

Figure 3: British Pendulum Tester

The specimen were air dried before placing them into the polishing machine. The steps for polishing were:

1. Place specimens into randomly selected housing component positions of the polisher.
2. Adjust housing component plate and bolt to raise or lower the specimen so it is level with the upper surface plate.

3. The clamp is tightened around the sample to prevent rotation from the wheels.
4. Verify the tires are inflated to 30 psi
5. Measure the hardness of the tire using a Durometer; the tire hardness was measured every 4000 cycles.
6. The temperature of each specimen surface, the tire tread, and tire sidewall is to be taken with an infrared thermometer.
7. 2 grams of Silicon Carbide abrasive powder is distributed on the surface of each specimen.
8. The wheel assembly is lowered.
9. Weights totaling 50 pounds are placed and secured on the wheel assembly fender.
10. The safety guards are placed in the upright position.
11. The breaker box for the machine is switched on.
12. If on initial cycles, the revolution cycle counter is reset to 0.
13. The variable frequency drive is placed to 0 and switched on.
14. The variable frequency drive is slowly increased to reach the 30 rev/min speed.
15. When desired number of revolutions is met, the polisher is stopped with the shut off button.
16. The safety guards are taken down.
17. The temperature of each specimen surface, tire tread, and tire sidewall is taken with an infrared thermometer.
18. The weights are taken off of the fenders.
19. The wheel assembly is lifted and locked into place.
20. The abrasive powder is cleaned off of specimen surfaces.
21. The clamps are loosened.
22. The samples are removed.

This procedure is performed for all polishing cycles during the experiment. The BPN is measured for each sample after each polishing cycle. The cumulative number of cycles between friction measurements were 2000, 4000, 8000, and 12,000 cycles. Since the polishing machine has four wheels, each revolution produces four wheel passes.

Figure 4: WVDOH Polishing Machine

Validate Experiment Repeatability

The polishing equipment and procedures are new developments that were only used by one researcher. Before this process can be implemented for making decisions about the skid resistance or friction of asphalt concrete it is important to verify the process is repeatable. The four asphalt mixes used by Hoyer (2020) were tested. The job mix formulas for these mixtures are in Appendix A. The four mixes are:

- J. F. Allen Co. – 12.5 mm Skid w/RAP (Mix 1)
- West Virginia Paving, Inc. – Wearing 1 w/RAP (Mix 2)
- Greer – Wearing 1 Heavy (Mix 3)
- West Virginia Paving, Inc. – 12.5 mm Skid w/RAP (Mix 4)

To duplicate Hoyer's experiment, two toe settings and two air voids for the samples were tested:

- Toe levels – Low at 2° and 4°, and High at 4° and 8°
- VTM – $4 \pm 0.5\%$ and $8 \pm 0.5\%$

In addition the tops and the bottoms of the samples were polished and tested, using the combinations described in Table 3.

Table 3: Combinations of mixtures used in testing

Series	Mixture Types	Specimen Side	Toe Angles
1	JFA 12.5mm Skid-RAP and WVP W1-RAP	Top	High Toe
2	JFA 12.5mm Skid-RAP and WVP W1-RAP	Bottom	Low Toe
3	Greer W1H and WVP 12.5mm Skid-RAP	Bottom	Low Toe
4	Greer W1H and WVP 12.5mm Skid-RAP	Top	High Toe

The results were statistically compared to Hoyer's results. Measurements are provided in Appendix B.

Skid Resistant Asphalt Experiment

A skid resistant experiment was developed by contractor J. F. Allen Co. Starting with an approved skid mix, three variations were made as described in Table 4. The aggregate characteristics are described in Appendix A.

Three specimens of each mixture were compacted and verified to the desired VTM of $7 \pm 0.5\%$. A VTM of 7% closely resembles field air voids in the field. A total of twelve samples were compacted for this experiment. The top and bottoms of the samples were tested using high and low toe angles, respectively. The polishing process was augmented with an additional 8,000 revolutions to ensure the minimum friction level reached. Measurement are provided in Appendix C.

Table 4: Skid resistant aggregate distribution in mixtures

Mixture Type	Percent Skid	Aggregate Composition*			
		8's (40%)	9's (10%)	Sand (49%)	Bag House Fines (1%)
All Skid	99	Skid	Skid	Skid	Non-Skid
Opposite Skid	59	Non-Skid	Skid	Skid	Non-Skid
Per Design	40	Skid	Non-Skid	Non-Skid	Non-Skid
No Skid	0	Non-Skid	Non-Skid	Non-Skid	Non-Skid

Insoluble Residue Test

The WVDOH uses the insoluble residue (IR) test, WVDOH MP 703.00.29, to evaluate carbonate aggregates for use as skid resistant aggregates for wearing surfaces of pavements with an ADT of 3000 or more. The aggregates used in the mixes from the skid resistant experiment were evaluated using MP 703.00.29. The samples for the IR test were obtained by burning of the G_{mm} samples used in the skid resistant experiment, following AASHTO T 308.

MP 703.00.29 specifies grinding down the aggregate sample to pass the No. 16 sieve. The IR test is then performed on the reduced material that is retained on the No. 30 sieve. For research purposes the IR of two additional gradations:

- the material passing the No. 30 and retained on the No. 200
- all the material passing the No. 16 and retained on the No. 200 sieve.

A total of 24 samples were evaluated based on four mix types, three test protocols, and two replicate samples. The amount of quartz material was observed, and the percentage of quartz was subjectively chosen from the comparison chart in the material procedure, shown in Figure 5. Measurements collected are provided in Appendix D.

Figure 5: Comparison Chart for Estimation of Percentage Composition (WVDOH MP 703.00.29)

Chapter 4: Results and Discussion

This section presents the results and provides discussion of the results found. The first section compares the results from the original experiment to the current replicate experiment to test repeatability. The second section concludes and compares the skid resistant aggregate experiment results to the insolubility residue test results. The data recorded for the results are displayed in the Appendix.

Comparison for Repeatability

Figures 6 to 9 compare the original polishing results to the replicate results for 48,000 wheel passes for the different variables in the experiment.

Figure 6: Average BPN After 48,000 Wheel Passes at 4% VTM with High Toe

Figure 7: Average BPN After 48,000 Wheel Passes at 8% VTM with High Toe

Figure 8: Average BPN After 48,000 Wheel Passes at 4% VTM with Low Toe

Figure 9: Average BPN After 48,000 Wheel Passes at 8% VTM with Low Toe

The statistical analysis using the t-Test: Two Sample Assuming Equal Variances data analysis in Excel produced the results in Table 5.

Table 5: Statistical comparison for original vs. replicate results

	<i>Original</i>	<i>Replicate</i>
Mean	44.8	40.5
Variance	11.1	4.4
Observations	48	48
Pooled Variance	7.75	
Hypothesized Mean Difference	0	
df	94	
t Stat	7.58	
P(T<=t) one-tail	1.20E-11	
t Critical one-tail	1.66	
P(T<=t) two-tail	2.41E-11	
t Critical two-tail	1.99	

The statistical comparison shows that the two-tail p-value is less than $\alpha=0.05$, so the null hypothesis of equal means is rejected. This concludes the test is not repeatable and further research is needed to refine the polishing protocol. Figure 10 compares the average BPN of the original experiment to the replicate experiment by finding the line of regression for the data.

Figure 10: Average BPN Comparison for Original vs. Replicate

To show similar results with a line of regression, a preferred y intercept is 0 and a preferred slope is 1x. The y intercept from this chart is 40.508, and the slope of the line is 0.1066x. The R^2 value for this chart equals 0.0045, showing that a low percentage of the data fit the line of regression.

Skid Resistant Asphalt Results

The progression of polishing for the Per Design #1 sample is shown in Figure 11. The illustration shows aggregates becoming more visible as the number of wheel passes increases.

Figure 11: Progression of polishing

The general trend of decreasing BPN with polishing cycles is shown on Figures 12 and 13 for high toe and low toe, respectively. The results for the different mixes appears to be similar.

Figure 12: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with High Toe

Figure 13: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with Low Toe

The comparison of the specimen at 80,000 wheel passes is shown in Figure 14. The summary of results from the skid resistant asphalt experiment at 80,000 wheel passes is shown in Table 6. The results are very similar. The average BPN and standard deviation of each sample type are shown in Table 6. The mixture with 59% skid resistant aggregates performed slightly higher than other mixtures.

Figure 14: Average BPN per specimen for Low Toe and High Toe after 80,000 Wheel Passes

Table 6: BPN Average and Standard Deviation

	Mix	Sample	Average of 4 BPN Measurements	Average of Samples	Standard Deviation
Bottom Low Toe	Per Design	1	44.3	44.3	1.00
		2	43.3		
		3	45.3		
	Opposite Skid	1	46.0	44.9	1.13
		2	45.0		
		3	43.8		
	No Skid	1	42.5	43.3	1.04
		2	44.5		
		3	43.0		
	All Skid	1	45.0	43.8	1.26
		2	42.5		
		3	44.0		
Tops High Toe	Per Design	1	44.3	44.0	0.43
		2	44.3		
		3	43.5		
	Opposite Skid	1	44.5	44.0	0.43
		2	43.8		
		3	43.8		
	No Skid	1	42.0	42.8	0.88
		2	42.8		
		3	43.8		
	All Skid	1	44.0	43.3	0.63
		2	42.8		
		3	43.3		

The further statistics that were performed on the average BPN results using a t-Test: Two-Sample Assuming Equal Variances in Excel are shown below in Table 7. This test compared the results of the average BPN when using low toe and high toe.

Table 7: t-Test results for average BPN of specimen at 80,000 wheel passes

	<i>Low Toe</i>	<i>High Toe</i>
Mean	44.1	43.5
Variance	1.27	0.54
Observations	12	12
Pooled Variance	0.904	
Hypothesized Mean Difference	0	
df	22	
t Stat	1.40	
P(T<=t) one-tail	0.088	
t Critical one-tail	1.72	
P(T<=t) two-tail	0.177	
t Critical two-tail	2.07	

This statistical comparison shows that the p-value is greater than $\alpha=0.05$, so there is insufficient evidence to reject the null hypothesis; indicating the test results for each toe angle are statistically similar.

The average BPN versus percent skid aggregate is shown in Figure 15. The graph appears to show a slight trend of increasing BPN with percent skid aggregate up to 40 to 59 percent aggregate then decreases to the 99 percent skid aggregate mix. However, with the amount of variability in the test results it cannot be concluded that there is a correlation between BPN and percent skid aggregate.

Figure 15: Skid Aggregate Content vs. Average BPN

The results from the insoluble residue test also indicate that average BPN value does not increase as the percentage of skid resistant aggregates increases. Table 8 displays the summary of results from the three insoluble residue tests. The percentage of insoluble aggregates found in the All Skid mixture is the largest in all three test methods, as expected. The Opposite Skid was expected to have the third largest percentage of insoluble residue, but instead, Per Design shows a larger percentage. This was expected for the method following the WVDOH precisely, but the other two methods were thought to be more representative of the sample. The WVDOH method only uses larger sized aggregates during testing, so the Opposite Skid was expected to show less insoluble residue since the skid aggregates pass through the desired sieve size. Figure 16 illustrates the insoluble residue values from the state approved WVDOH MP 703.00.29 and the additional variations of tests per each skid aggregate content.

Table 8: Summary of average Insoluble Residue results per sample for each method

	+200 Qtz.,%: Per Sample Averages			
	All Skid	Opposite Skid	Per Design	No Skid
Percent Skid Aggregate	99	59	40	0
DOH Method	12	3	11	1
Under DOH	24	9	22	5
Total IR	18	11	13	6

Figure 16: Skid Aggregate Content vs. +200 Quartz Insoluble Residue

Comparing the values from the test following the DOH Method, it can be seen the average BPN values for each sample do not correlate to the insoluble residue results. These results can be seen in Table 9. Table 10 shows how these results compare to each other when ranked. The Per Design and No Skid had consistent rankings, but the All Skid and Opposite Skid had varying rankings.

Table 9: Insoluble Residue (% Quartz) vs. Average BPN

	IR value (% Qtz)	High Toe Average BPN	Low Toe Average BPN
All Skid	12	43.3	43.8
Opposite Skid	3	44.0	44.9
Per Design	11	44.0	44.3
No Skid	1	42.8	43.3

Table 10: Ranking of IR and BPN

	IR Ranking	Average BPN Ranking
All Skid	1	3
Opposite Skid	3	1
Per Design	2	2
No Skid	4	4

Figure 17 displays example images of the microscopic view for various sample mixtures and sieve sizes. These images were compared to the comparison chart in the MP 703.00.29, Figure 5, to determine the insoluble residue contents.

Figure 17: *Microscopic view of Insoluble Residue*

Chapter 5: Conclusions and Recommendations

Conclusions

This research had multiple objectives pertaining to skid resistant aggregates and their microtexture properties. The testing was performed using the CTPM and the BPT, aside from the insoluble residue portion.

During the repeatability test, all procedures were carefully followed exactly as the previous experimenter. The preparation of the samples was performed in the same way and tested in the same order. Discrepancies in the data could have happened in the polishing process or during testing. Since the testing procedure with the BPT involves applying 30 sprays of water, this could have affected the BPN. The amount of 1 spray could have varied by experimenter. Having a way of applying an exact amount of water each time could change the variances in the results. One mixture during testing was inconsistent during compaction; the desired VTM was difficult to achieve. This could have affected the way the asphalt polished, creating different results and different statistics.

During the skid resistant aggregate experiment, the average BPN results for each mixture type were very similar to each other, suggesting that there is no difference in their performance is regards to microtexture using the BPT.

When determining the insoluble residue content, the results show that there are no correlations to the amount of apparent skid aggregates in the mix and the amount found after the insoluble residue test. Since the test is very subjective to the one performing the test, the content of the insoluble residue could be different.

The data collected from this study result in the following conclusions:

- The null hypothesis that the polishing method is repeatable is false.
- Further research is needed to refine the polishing procedure.
- There is no correlation between the microtexture skid resistance performance of asphalt and the amount of skid resistant aggregate in the mixture when using the BPT.

- Insoluble residue percentage does not correlate to the average BPN.
- Ranking of the mixtures was inconsistent between the Polishing and IR methods.

Recommendations

Additional research of various friction measurements is needed. When finding the skid resistance of a pavement, testing should be performed at a higher speed in order to mimic traffic that travels at a higher speed. The BPT is used for low speed testing. A device for high speed testing should be used to accurately mimic the effects of skid resistant aggregates in asphalt.

The data for the skid aggregate samples was taken using a mix design from a single contractor. It is recommended to do the testing with the same mix designs made from other contractors to see if all mixes would perform the same as the specimens in this experiment. Running additional cycles in the polishing machine to polish off more binder and expose aggregate could produce different results as well. Additionally, the WVDOH should consider using other methods for evaluating friction and skid resistance for laboratory testing.

References

- Ahmad, Shaheer. 2015. "Experiment No.6, To Measure Surface Frictional Properties Using British Pendulum Skid Resistance Tester." Accessed March 12, 2020. https://www.academia.edu/37842764/To_Measure_Surface_Frictional_Properties_Using_British_Pendulum_Skid_Resistance_Tester
- Chen, X., Dai, S., Guo, Y., Yang, J., and Huang, X., "Polishing of Asphalt Pavements: From Macro- to Micro- Scale," *Journal of Testing and Evaluation*, Vol. 44, No. 2, 2016, pp. 885–894, doi:10.1520/JTE20150271. ISSN 0090-3973
- Dahir, S. H. M. and Mullen, W.G. 1971 "Factors Influencing Aggregate Skid-Resistance Properties." <http://onlinepubs.trb.org/Onlinepubs/hrr/1972/376/376-022.pdf>
- Federal Highway Administration. February 20, 2020. "How Do Weather Events Impact Roads?." Accessed March 2, 2020. https://ops.fhwa.dot.gov/weather/q1_roadimpact.htm
- Federal Highway Administration. June 17, 2005. "Technical Advisory T 5040.36 Surface Texture for Asphalt and Concrete Pavements." Accessed March 2, 2020. <https://www.fhwa.dot.gov/pavement/t504036.cfm>
- Federal Highway Administration Research and Technology. February 2015. "Evaluation of Pavement Safety Performance." Accessed March 3, 2020. <https://www.fhwa.dot.gov/publications/research/safety/14065/002.cfm>
- Henry, John. (2000). "Evaluation of Pavement Friction Characteristics." NCHRP Synthesis 291.
- Hoyer, D. (2020) "Procedure for Asphalt Mixture Friction Evaluation for WVDOH." West Virginia University
- Jayawickrama, Priyantha W., Rachakatla, P., and Thomas, B. September 1998. "A Comprehensive Methodology for Predicting Field Skid Resistance of Bituminous Aggregates Based on Laboratory Test Data as Well as Their Skid Performance." Texas Tech University. <https://library.ctr.utexas.edu/hostedpdfs/texastech/0-1459-5f.pdf>
- Liang, Robert Y. August 2003. "Blending Proportions of High Skid and Low Skid Aggregate." The University of Akron. <http://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Reports/2003/Materials/14793-FR.pdf>
- Lu, Qing. (2006). Friction Testing of Pavement Preservation Treatments: Literature Review.
- Masad, E., Rezaei, A., Chowdhury, A., and Harris, P. August 2009. "Predicting Asphalt Mixture Skid Resistance Based on Aggregate Characteristics." Texas Transportation Institute. <https://static.tti.tamu.edu/tti.tamu.edu/documents/0-5627-1.pdf>
- Mataei, B., Zakeri, H., Zahedi, M. and Nejad, F.M. (2016) Pavement Friction and Skid Resistance Measurement Methods: A Literature Review. *Open Journal of Civil Engineering*, 6, 537-565. <http://dx.doi.org/10.4236/ojce.2016.64046>
- O'Brien, Joan P., and Haddock, John E. September 2009. "Frictional Resistance of Aggregates for Hot-Mix Asphalt Pavements." FHWA A/IN/JTRP-2004/23. Purdue University. <https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2563&context=jtrp>

List of Test Methods Used

- AASHTO R 83: *Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor*. Washington, DC: American Association of State Highway and Transportation Officials, 2018.
- AASHTO T 166: *Bulk Specific Gravity (Gmm) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens*. Washington, DC: American Association of State Highway and Transportation Officials, 2018.
- AASHTO T 209: *Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA)*. Washington, DC: American Association of State Highway and Transportation Officials, 2018.
- AASHTO T 278: *Surface Frictional Properties Using the British Pendulum Tester*. Washington, DC: American Association of State Highway and Transportation Officials, 2018.
- AASHTO T 308: *Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method*. Washington, DC: American Association of State Highway and Transportation Officials, 2018.
- ASTM D3042: *Standard Test Method for Insoluble Residue in Carbonate Aggregates*. Pennsylvania: ASTM International, 2017.
- ASTM E303: *Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester*. Pennsylvania: ASTM International, 2018.
- ASTM E660: *Standard Practice for Accelerated Polishing of Aggregates or Pavement Surfaces Using a Small-Wheel, Circular Track Polishing Machine*. Pennsylvania: ASTM International, 2015.
- WVDOH MP 402.02.20: *Rapid Determinations of the Polish Susceptible Carbonate Particle Content in Aggregates*. West Virginia Department of Transportation, Division of Highways. 1995.
- WVDOH MP 703.00.20: *Determining Percent Quartz in Content Aggregates*. West Virginia Department of Transportation, Division of Highways. 2018.

Appendix A: Mix Design

Job Mix Formulas

T400 SP
04-10

WVDOH MCS&T Approval

Recommended for Approval:

P. Cyrus

Approved By:

03/14/2018

WEST VIRGINIA DIVISION OF HIGHWAYS JOB MIX FORMULA FOR SUPERPAVE HOT-MIX ASPHALT

Report Number:		1462122		Date Accepted:		March 6, 2018	
HMA Type:		12.5 mm Skid - RAP		HMA Code:		402.002.015	
Producer:		J. F. Allen Company		Plant Location:		Lorentz, WV	
Designed By:		Chadley Miller		Design Lab:		J. F. Allen (Elkins, WV)	
Plant Type:		Batch		Plant Make:		McCarter	
Plant Code:		JFA1.02.400		Design ESALs:		3 to < 30 Million (3)	

MIX COMPOSITION									
Coarse Aggregate Source				Code		Fine Aggregate Source		Code	
CA₁	J.F Allen Company (Mashey Gap, WV)			JFA2.01.704		FA₁	J.F Allen Company (Elkins, WV)		
CA₂	J.F Allen Company (Mashey Gap, WV)			JFA2.01.704		FA₂			
CA₃						FA₃			
		CA₁	CA₂	CA₃		FA₁	FA₂	FA₃	
Agg. Type		#76 Skid		#8 Skid		L. Stone Sand			
Agg. Code		703.001.078		703.001.008		702.003.001			
% Total Agg.		20		37		33			
% RAP Total Agg.:		10		Blended Binder G*/sin delta if > 25% RAP:					
% Binder In RAP Design:		4.7		Binder Type:		PG 64H-22		Binder Code:	705.005.009
Binder Source:		Marathon Petroleum - Floreffe				Binder Source Code:		MPC1.02.705	

Sieve Fraction						Fines / Effective Asphalt Ratio		Tensile Strn. Ratio	
Sieve Size	Target	Allowable		Sieve Size	Target	Allowable		0.9	84.9
		Min.	Max.			Min.	Max.		
2" (50 mm)				#4 (4.75 mm)	52			Temperature Range Completed Mixture (°F) Desirable Temp. Range Mean Temp. Min. Max.	
1.5" (37.5mm)				#8 (2.36 mm)	35	29	41		
1" (25 mm)				#16 (1.18 mm)	22				
3/4" (19 mm)	100	100	100	#30 (600 µm)	14			Temperature Range Completed Mixture (°F) Desirable Temp. Range Mean Temp. Min. Max.	
1/2" (12.5mm)	95	90	100	#50 (300 µm)	9				
3/8" (9.5 mm)	82		90	#200 (75 µm)	4.1	2.0	10.0		
								316	291 341

JOB MIX FORMULA VALUES					
Specific gravity stone bulk (Gsb):	Design Property	Job Mix Formula		Job Mix Formula Tolerances	
		Design Targets	Minimum	Maximum	Maximum
2.656	Asphalt (%)	5.4	5.0	5.8	
	Air Voids (%)	4.0	2.8	5.2	
Maximum Density (kg/m ³)	VMA (%)	14.6	14.0	16.0	
	VFA (%)	73	72	79	
2498					
Gyrations @ N _{design} :	80	Desirable Mean Temp. for Lab. Specimens (°F):		Comp. Temp. :	296
Mixing Temp. :		316			
Remarks: <div style="border: 1px solid black; padding: 5px; display: inline-block;">Sister Version: 1462123</div>					

Figure 18: Job Mix Formula for J. F. Allen Co. – 12.5 mm SKID – RAP

T400
04-10

0CF .17

Approved 3/18/2015

WEST VIRGINIA DIVISION OF HIGHWAYS
JOB MIX FORMULA FOR HOT-MIX ASPHALT

Report Number:	1436773	Date Accepted:	March 18, 2015
HMA Type:	Wearing 1-RAP	HMA Code:	13971
Producer:	Southern WV Asphalt	Plant Location:	Huntington, WV
Designed By:	Wayne Ingram	Design Lab:	Southern WV Asphalt-Ingleside, WV
Plant Type:	Drum	Plant Make:	Cedarapids
Plant Code:	H0250	Traffic Type:	Medium

MIX COMPOSITION							
Coarse Aggregate Source			Code	Fine Aggregate Source			Code
CA ₁	Mountain Material-Olive Hill, KY		M378A	FA ₂	Letart S & G, Gallipolis Ferry, WV		E006A
CA ₂				FA ₃	Mountain Slag-Greenup, KY		M365A
FA ₁	Brushy Creek Stone-Olive Hill, KY		S044F	FA ₄	Bag House Fines (BHF)		10000
	CA ₁	CA ₂	FA ₁	FA ₂	FA ₃	FA ₄	
Agg. Type	#8 Limestone		Limestone	Natural	Slag	BHF	
Agg. Code	1135		1116	1115	1114	1116	
% Total Agg.	40		4	30	10	1	
% RAP Total Agg.:		15		Blended Binder G*/sin delta if > 25% RAP:			
% Binder In RAP Design:		5.2		Binder Type:	PG 64-22	Binder Code:	1093
Binder Source:		Shelly Liquid Division-Kanauga, OH				Binder SourceCode:	M001A

Sieve Fraction								Voids filled with Asphalt (VFA) %	Fines to Asphalt Ratio
Sieve Size	Target	Allowable		Sieve Size	Target	Allowable		78	1.0
		Min.	Max.			Min.	Max.		
2" (50 mm)				#4 (4.75 mm)	63		80	Temperature Range Completed Mixture (°F)	
1.5" (37.5 mm)				#8 (2.36 mm)	50	43	55		
1" (25 mm)				#16 (1.18 mm)	42			Desirable Mean Temp.	Temp. Range Min. Max.
3/4" (19 mm)				#30 (600 µm)	33				
1/2" (12.5 mm)	100	100	100	#50 (300 µm)	13				
3/8" (9.5 mm)	96	85	100	#200 (75 µm)	5.8	2.0	9.0	311	286 336

JOB MIX FORMULA VALUES				
Specific gravity stone bulk (Gsb): 2.678	Design Property	Job Mix Formula	Job Mix Formula Tolerances	
		Design Targets	Minimum	Maximum
Maximum Density (kg/m ³) 2445	Asphalt (%)	6.1	5.7	6.5
	Air Voids (%)	4.0	2.5	5.5
	VMA (%)	17.7	16.7	18.7
	Stability (N)	13427	5300	NA
	Flow (0.25mm)	9.0	8	16
Desirable Mean Temperature for Laboratory Specimens (°F):		Compaction Temperature:	287	Mixing Temperature:
Remarks: <i>See Report 2-16-16 4-0-16</i>		2.554 2018		310

Figure 19: Job Mix Formula for West Virginia Paving, Inc. – Wearing 1 – RAP

T400
03-00

WEST VIRGINIA DIVISION OF HIGHWAYS JOB MIX FORMULA FOR HOT-MIX ASPHALT

Report Number:	1360465	Date Accepted:	March 9, 2004
HMA Type:	Wearing-1	HMA Code:	13966
Producer:	Greer Asphalt	Plant Location:	Greer, WV
Designed By:	Rich Nuzum	Design Lab:	Clarksburg Asphalt
Plant Type:	Batch	Plant Make:	McCarter
Plant Code:	G012A	Traffic Type:	Heavy

MIX COMPOSITION						
Coarse Aggregate Source		Code	Fine Agg. / Mineral Filler Source		Code	
CA ₁	Greer Industries, Greer, WV	G0120	FA ₁	Greer Industries, Greer, WV	G0120	
CA ₂			FA ₂	Greer Industries, Greer, WV	G0120	
CA ₃			FA ₃			
	CA ₁	CA ₂	CA ₃	FA ₁	FA ₂	FA ₃
Agg. Type	#8 Limestone			Limestone	Limestone	
Agg. Code	1135			1116	1116	
% Total Agg.	48			32	20	
% RAP Total Agg.:		Blended Binder G*/sin delta if > 25% RAP:				
% Binder In RAP Design:		Binder Type:		PG 64-22	Binder Code:	1093
Binder Source:		Marathon/Ashland Oil, Floreffe, Pa.			Binder SourceCode:	A022B

Sieve Fraction								Voids filled with Asphalt "VFA" (%)	Fines to Asphalt Ratio
Sieve Size	Target	Allowable		Sieve Size	Target	Allowable		75	0.8
		Min.	Max.			Min.	Max.		
2" (50 mm)				#4 (4.75 mm)	60		80	Temperature Range Completed Mixture (°F)	
1.5" (37.5 mm)				#8 (2.36 mm)	39	33	45		
1" (25 mm)				#16 (1.18 mm)	23			Desirable Mean Temp.	Temp. Range Min. Max.
3/4" (19 mm)				#30 (600 µm)	12				
1/2" (12.5 mm)	100	100	100	#50 (300 µm)	7			295	270 320
3/8" (9.5 mm)	95	85	100	#200 (75 µm)	4.4	2.0	9.0		

JOB MIX FORMULA VALUES				
Job Mix Formula Targets			Job Mix Formula Tolerances	
Specific gravity stone bulk (G _{sb}):	Design Property	Accepted Target	Minimum	Maximum
2.662	Asphalt (%)	5.7	5.3	6.1
Maximum Density (kg/m ³)	Air Voids (%)	4.0	2.5	5.5
	VMA (%)	15.7	14.7	16.7
	Stability (N)	10400	8000	NA
2476	Flow (0.25mm)	11	8	14

Remarks:

Figure 20: Job Mix Formula for Greer – Wearing 1 Heavy

T400SP
04-10

WVDOH MCS&T Approval

Recommended for Approval:

P. Cyrus

Approved By:

03/14/2018

**WEST VIRGINIA DIVISION OF HIGHWAYS
JOB MIX FORMULA FOR SUPERPAVE HOT-MIX ASPHALT**

Report Number:		1462115		Date Accepted:		February 27, 2018	
HMA Type:		12.5 mm Skid-RAP		HMA Code:		402.002.015	
Producer:		West Virginia Paving, Inc		Plant Location:		Dunbar, WV	
Designed By:		Jason Frame/Jack Withrow		Design Lab:		WV Paving-Dunbar, WV	
Plant Type:		Drum		Plant Make:		ASTEC	
Plant Code:		WVP1.02.400		Design ESALs		3 to < 30 million	

MIX COMPOSITION							
Coarse Aggregate Source			Code	Fine Aggregate Source			Code
CA ₁	Mulzer Stone-Charlestown, IN		MCS2.02.704	FA ₁	Mulzer Stone-Cape Sandy, IN		MCS2.01.704
CA ₂	Appalachian Aggregates-Beckley, WV		BAC1.01.704	FA ₂	Mulzer Stone-New Amsterdam, IN		MCS2.03.704
CA ₃				FA ₃			
CA ₄				FA ₄	Bag House Fines		WVP1.02.400

	CA ₁	CA ₂	CA ₃	CA ₄	FA ₁	FA ₂	FA ₃	FA ₄
Agg. Type	#78 Limestone-Skid	#8 Sandstone			Limestone (W)	Limestone #10 (W)		BHF
Agg. Code	703.001.078	703.001.008			702.003.001	702.003.001		702.003.001
% Total Agg.	22	22			20	20		1

% RAP Total Agg.:		15		Blended Binder G*/sin delta if > 25% RAP:			
% Binder In RAP Design:		5.0		Binder Type:		PG 64H-22	
Binder Source:		Shelly Liquid Division-Kanauga, OH				Binder SourceCode:	
						705.005.008	
						SLD1.01.705	

Sieve Fraction								Fines/Effective Asphalt Ratio	Tensil Strn. Ratio
Sieve Size	Target	Allowable		Sieve Size	Target	Allowable		1.1	90.3
		Min.	Max.			Min.	Max.		
2" (50 mm)				#4 (4.75 mm)	60			Temperature Range Completed Mixture (°F)	
1.5" (37.5mm)				#8 (2.36 mm)	37	31	43		
1" (25 mm)				#16 (1.18 mm)	24				
3/4" (19 mm)	100	100	100	#30 (600 µm)	17				
1/2" (12.5 mm)	93	90	100	#50 (300 µm)	12			Desirable Mean Temp.	Temp. Range Min. Max.
3/8" (9.5 mm)	85		90	#200 (75 µm)	5.5	2.0	10.0	329	304 354

JOB MIX FORMULA VALUES					
		Job Mix Formula		Job Mix Formula Tolerances	
Specific gravity stone bulk (G _{sb}):	Design Property	Design Targets		Minimum	Maximum
2.612	Asphalt (%)	5.9		5.5	6.3
Maximum Density (kg/m ³)	Air Voids (%)	4.0		2.8	5.2
	VMA (%)	15.2		14.2	16.2
	VFA (%)	74		72	79
Gyrations @ N _{design}	80	Desirable Mean Temp. for Lab. Specimens (°F):		Comp. Temp.:	308
				Mixing Temp.:	329

Remarks:	Additional information for this JMF can be found in the accompanying 12.5mm RAP PG 64-22 mix design packet (JMF#1462114).				
----------	---	--	--	--	--

Figure 21: Job Mix Formula for West Virginia Paving, Inc. – 12.5 mm Skid – RAP

T400 SP
04-10

**WEST VIRGINIA DIVISION OF HIGHWAYS
JOB MIX FORMULA FOR SUPERPAVE HOT-MIX ASPHALT**

Report Number: 1420918		Date Accepted: March 11, 2011	
HMA Type: 9.5 mm <i>SKID</i>		HMA Code: 13244	
Producer: J. F. Allen Company		Plant Location: Elkins, WV	
Designed By: Chadley Miller		Design Lab: J. F. Allen, Elkins, WV	
Plant Type: Drum		Plant Make: Astec	
Plant Code: A007A		Design ESALs: 3 < 30 million (3)	

MIX COMPOSITION							
Coarse Aggregate Source			Code	Fine Aggregate Source			Code
CA ₁	J. F. Allen Company, Mashey Gap, WV		A007E	FA ₁	J. F. Allen Company, Elkins, WV		A007A
CA ₂				FA ₂	J. F. Allen Company, Elkins, WV		A007A
CA ₃				FA ₃	Bag House Fines (BHF)		I0000
	CA ₁	CA ₂	CA ₃	FA ₁	FA ₂	FA ₃	
Agg. Type	#8 Limestone			#9 Limestone	Limestone	BHF	
Agg. Code	1135			1137	1116	1116	
% Total Agg.	40			10	49	1	
% RAP Total Agg.:			Blended Binder G*/sin delta if > 25% RAP:				
% Binder In RAP Design:			Binder Type:	PG 70 - 22	Binder Code:	1091	
Binder Source:			Marathon Petroleum, Catlettsburg, KY		Binder Source Code:	A022A	

Sieve Fraction								Fines / Effective	Tensile
Sieve Size	Target	Allowable		Sieve Size	Target	Allowable		Asphalt Ratio	Strn. Ratio
		Min.	Max.			Min.	Max.	1.0	80.0
2" (50 mm)				#4 (4.75 mm)	70		90	Temperature Range	
1.5" (37.5 mm)				#8 (2.36 mm)	45	39	51	Completed Mixture (°F)	
1" (25 mm)				#16 (1.18 mm)	27			Desirable	Temp. Range
3/4" (19 mm)				#30 (600 µm)	17			Mean Temp.	Min. Max.
1/2" (12.5 mm)	100	100	100	#50 (300 µm)	10				
3/8" (9.5 mm)	99	90	100	#200 (75 µm)	5.4	2.0	10.0	328	303 353

JOB MIX FORMULA VALUES				
Specific gravity stone bulk (Gsb): 2.647	Design Property	Job Mix Formula Design Targets	Job Mix Formula Minimum	Job Mix Formula Maximum
	Asphalt (%)	6.0	5.6	6.4
Maximum Density (kg/m³) 2461	Air Voids (%)	4.0	2.8	5.2
	VMA (%)	16.1	15.1	17.1
	VFA (%)	75	74	80
Gyrations @ N design:	80	Desirable Mean Temp. for Lab. Specimens (°F):	Comp. Temp.:	306
			Mixing Temp.:	328

Remarks:

6.0% @ 2.4

Figure 22: Job Mix Formula for J. F. Allen Co. – 9.5 mm SKID - Per Design Mixture

Batch Sheets

DATE: 9/9/19

Project Number : 9.5 mm SUPERPAVE - WVU Skid Study

Aggr.1 = MASHEY GAP SKID 8'S

Aggr.2 = ELKINS 9'S

Aggr.3 = ELKINS SAND

Aggr.4 = BAG HOUSE FINES

Aggr.5 =

MIX 4 Batches

No Skid

Mixture Testing Weights - Scale Weights

Batch weight =		9500.0	grams		
% Bin Splits =>		40%	10%	49%	1%
Sieve Size		MG	ELK	ELK	
mm	US	8'S	9'S	SAND	BHF
50	2"				
37.5	1 1/2"				
25	1"				
100.0	19	3/4"			
100.0	12.5	1/2"			
99.0	9.5	3/8"	95.0		
69.4	4.75	#4	2705.9	4004.3	
44.8	2.36	#8	3640.9	4659.0	5490.2
27.5	1.18	#16	3705.8	4714.4	7022.1
16.9	0.6	#30	3728.8	4719.1	7999.8
10.0	0.3	#50	3736.7	4719.9	8646.6
7.8	0.15	#100	3744.6	4720.7	8846.9
5.3	0.075	#200	3752.5	4724.7	9060.6
Pan		3800.0	4750.0	9405.0	9500.0
Totals		3800.0	950.0	4655.0	95.0
					0.0

Asphalt Needed per batch

Specimen #	1	2	3	4	5
Enter Pb			5.7%		
Mb needed			574.2		

grams

Figure 23: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - No Skid Mixture

DATE: 9/9/19

Project Number : 9.5 mm SUPERPAVE - WVU Skid Study

Aggr.1 = MASHEY GAP SKID 8'S

Aggr.2 = ELKINS 9'S

Aggr.3 = ELKINS SAND

Aggr.4 = BAG HOUSE FINES

Aggr.5 =

MIX 4 Batches

Per Design

Mixture Testing Weights - Scale Weights						
Batch weight =		9500.0	grams			
% Bin Splits =>		40%	10%	49%	1%	
Sieve Size		MG SKID	ELK	ELK		
mm	US	8'S	9'S	SAND	BHF	
50	2"					
37.5	1 1/2"					
25	1"					
100.0	19	3/4"				
100.0	12.5	1/2"				
99.0	9.5	3/8"	95.0			
69.4	4.75	#4	2705.9	4004.3		
44.8	2.36	#8	3640.9	4659.0	5490.2	
27.5	1.18	#16	3705.8	4714.4	7022.1	
16.9	0.6	#30	3728.8	4719.1	7999.8	
10.0	0.3	#50	3736.7	4719.9	8646.6	
7.8	0.15	#100	3744.6	4720.7	8846.9	
5.3	0.075	#200	3752.5	4724.7	9060.6	
Pan			3800.0	4750.0	9405.0	9500.0
Totals			3800.0	950.0	4655.0	95.0
						0.0

Asphalt Needed per batch

Specimen #	1	2	3	4	5
Enter Pb			5.7%		
Mb needed			574.2		

grams

$$574.2 \div 94.3$$

Figure 24: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - Per Design Mixture

DATE: 9/9/19

Project Number : 9.5 mm SUPERPAVE - WVU Skid Study

Aggr.1 = MASHEY GAP SKID 8'S

Aggr.2 = ELKINS 9'S

Aggr.3 = ELKINS SAND

Aggr.4 = BAG HOUSE FINES

Aggr.5 =

MIX 4 Batches

Opposite Skid

Mixture Testing Weights - Scale Weights									
Batch weight =		9500.0		grams					
% Bin Splits =>		40%		10%		49%		1%	
Sieve Size		MG		ELK		SKID		BHF	
mm US		8'S		9'S		SAND			
50	2"								
37.5	1 1/2"								
25	1"								
100.0	19	3/4"							
100.0	12.5	1/2"							
99.0	9.5	3/8"		95.0					
69.4	4.75	#4		2705.9		4004.3			
44.8	2.36	#8		3640.9		4659.0		5490.2	
27.5	1.18	#16		3705.8		4714.4		7022.1	
16.9	0.6	#30		3728.8		4719.1		7999.8	
10.0	0.3	#50		3736.7		4719.9		8646.6	
7.8	0.15	#100		3744.6		4720.7		8846.9	
5.3	0.075	#200		3752.5		4724.7		9060.6	
Pan				3800.0		4750.0		9405.0	
Totals				3800.0		950.0		4655.0	
								95.0	
								0.0	

Asphalt Needed per batch

Specimen #	1	2	3	4	5
Enter Pb			5.7%		
Mb needed			574.2		
grams					

Figure 25: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - Opposite Skid Mixture

DATE: 9/9/19

Project Number : 9.5 mm SUPERPAVE - WVU Skid Study

Aggr.1 = MASHEY GAP SKID 8'S

Aggr.2 = ELKINS 9'S

Aggr.3 = ELKINS SAND

Aggr.4 = BAG HOUSE FINES

Aggr.5 =

MIX 4 Batches

All Skid

Mixture Testing Weights - Scale Weights						
Batch weight =		9500.0	grams			
% Bin Splits =>		40%	10%	49%	1%	
Sieve Size		MG SKID	ELK	SKID		
mm	US	8'S	9'S	SAND	BHF	
50	2"					
37.5	1 1/2"					
25	1"					
100.0	19	3/4"				
100.0	12.5	1/2"				
99.0	9.5	3/8"	95.0			
69.4	4.75	#4	2705.9	4004.3		
44.8	2.36	#8	3640.9	4659.0	5490.2	
27.5	1.18	#16	3705.8	4714.4	7022.1	
16.9	0.6	#30	3728.8	4719.1	7999.8	
10.0	0.3	#50	3736.7	4719.9	8646.6	
7.8	0.15	#100	3744.6	4720.7	8846.9	
5.3	0.075	#200	3752.5	4724.7	9060.6	
Pan		3800.0	4750.0	9405.0	9500.0	
Totals		3800.0	950.0	4655.0	95.0	0.0

Asphalt Needed per batch

Specimen #	1	2	3	4	5
Enter Pb			5.7%		
Mb needed			574.2		

grams

Figure 26: Batch Sheet for J. F. Allen Co. – 9.5 mm SKID - All Skid Mixture

Appendix B: Replicate Study Data

Table 11: BPN data for Series 1 specimen

Mix No.	Mix Name	Sample Name	Wheel Passes	Trial 1	Trial 2	Trial 3	Trial 4
1	JF Allen 12.5mm SKID - 4%	S1	0	72	73	73	73
		S2	0	71	70	70	69
		S3	0	71	70	70	68
1	JF Allen 12.5mm SKID - 8%	S4	0	73	71	70	69
		S5	0	68	67	67	68
		S6	0	72	71	71	71
2	WV Pav W1-RAP - 4%	S7	0	75	74	72	70
		S8	0	75	74	73	73
		S9	0	78	80	77	77
2	WV Pav W1-RAP - 8%	S10	0	78	78	78	78
		S12	0	75	78	74	76
		S13	0	77	76	74	74
1	JF Allen 12.5mm SKID - 4%	S1	8,000	54	52	52	52
		S2	8,000	55	54	53	52
		S3	8,000	54	53	52	51
1	JF Allen 12.5mm SKID - 8%	S4	8,000	55	53	54	52
		S5	8,000	53	51	51	51
		S6	8,000	55	55	54	53
2	WV Pav W1-RAP - 4%	S7	8,000	59	57	56	56
		S8	8,000	57	56	55	54
		S9	8,000	59	56	54	55
2	WV Pav W1-RAP - 8%	S10	8,000	56	55	55	54
		S12	8,000	54	55	54	53
		S13	8,000	57	56	56	55
1	JF Allen 12.5mm SKID - 4%	S1	16,000	46	47	45	43
		S2	16,000	47	46	46	44
		S3	16,000	48	46	44	45
1	JF Allen 12.5mm SKID - 8%	S4	16,000	48	47	47	47
		S5	16,000	48	48	47	47
		S6	16,000	47	47	47	46
2		S7	16,000	52	48	51	50
		S8	16,000	52	51	50	49

	WV Pav W1-RAP - 4%	S9	16,000	52	50	50	50
2	WV Pav W1-RAP - 8%	S10	16,000	55	54	53	52
		S12	16,000	54	53	51	47
		S13	16,000	56	54	52	52
1	JF Allen 12.5mm SKID - 4%	S1	32,000	43	42	41	41
		S2	32,000	45	44	43	42
		S3	32,000	45	44	42	42
1	JF Allen 12.5mm SKID - 8%	S4	32,000	46	45	44	43
		S5	32,000	45	44	43	43
		S6	32,000	46	43	44	42
2	WV Pav W1-RAP - 4%	S7	32,000	47	45	45	45
		S8	32,000	48	47	46	46
		S9	32,000	47	47	46	45
2	WV Pav W1-RAP - 8%	S10	32,000	47	47	46	46
		S12	32,000	50	47	46	46
		S13	32,000	49	48	47	46
1	JF Allen 12.5mm SKID - 4%	S1	48,000	43	42	41	40
		S2	48,000	42	40	38	39
		S3	48,000	43	42	41	41
1	JF Allen 12.5mm SKID - 8%	S4	48,000	42	40	40	39
		S5	48,000	41	39	38	38
		S6	48,000	43	42	40	40
2	WV Pav W1-RAP - 4%	S7	48,000	46	45	44	44
		S8	48,000	45	44	43	42
		S9	48,000	44	43	42	41
2	WV Pav W1-RAP - 8%	S10	48,000	45	43	42	42
		S12	48,000	44	43	43	42
		S13	48,000	45	44	44	42

Table 12: BPN data for Series 2 specimen

Mix No.	Mix Name	Sample Name	Wheel Passes	Trial 1	Trial 2	Trial 3	Trial 4
1	JF Allen 12.5mm SKID - 4%	S1	0	64	62	62	61
		S2	0	67	64	63	62
		S3	0	66	64	63	62
1	JF Allen 12.5mm SKID - 8%	S4	0	64	63	62	61
		S5	0	64	62	61	61
		S6	0	68	66	66	66
2	WV Pav W1-RAP - 4%	S7	0	71	70	70	69
		S8	0	69	69	69	67
		S9	0	73	73	73	73
2	WV Pav W1-RAP - 8%	S10	0	71	69	69	68
		S12	0	74	74	73	72
		S13	0	71	71	69	68
1	JF Allen 12.5mm SKID - 4%	S1	8,000	51	50	49	48
		S2	8,000	51	50	49	49
		S3	8,000	51	50	50	49
1	JF Allen 12.5mm SKID - 8%	S4	8,000	53	51	50	49
		S5	8,000	54	52	52	51
		S6	8,000	52	51	51	50
2	WV Pav W1-RAP - 4%	S7	8,000	54	54	53	53
		S8	8,000	57	56	54	54
		S9	8,000	55	55	54	53
2	WV Pav W1-RAP - 8%	S10	8,000	58	57	55	54
		S12	8,000	58	57	56	55
		S13	8,000	56	54	54	54
1	JF Allen 12.5mm SKID - 4%	S1	16,000	45	43	43	43
		S2	16,000	46	46	45	44
		S3	16,000	47	46	44	44
1	JF Allen 12.5mm SKID - 8%	S4	16,000	47	46	45	45
		S5	16,000	47	46	45	45
		S6	16,000	47	45	45	44
2	WV Pav W1-RAP - 4%	S7	16,000	52	50	49	49
		S8	16,000	52	50	50	49
		S9	16,000	51	49	49	48
2		S10	16,000	52	50	50	50

	WV Pav W1-RAP - 8%	S12	16,000	53	51	50	50
		S13	16,000	53	52	51	49
1	JF Allen 12.5mm SKID - 4%	S1	32,000	42	41	41	41
		S2	32,000	43	42	42	41
		S3	32,000	44	42	41	41
1	JF Allen 12.5mm SKID - 8%	S4	32,000	43	41	41	41
		S5	32,000	45	44	43	42
		S6	32,000	44	43	43	43
2	WV Pav W1-RAP - 4%	S7	32,000	47	47	47	46
		S8	32,000	49	48	47	47
		S9	32,000	48	47	47	46
2	WV Pav W1-RAP - 8%	S10	32,000	48	47	46	46
		S12	32,000	50	48	47	46
		S13	32,000	49	48	47	47
1	JF Allen 12.5mm SKID - 4%	S1	48,000	40	38	38	38
		S2	48,000	39	38	37	37
		S3	48,000	39	39	39	38
1	JF Allen 12.5mm SKID - 8%	S4	48,000	41	39	39	38
		S5	48,000	41	39	39	39
		S6	48,000	40	39	39	39
2	WV Pav W1-RAP - 4%	S7	48,000	44	42	43	41
		S8	48,000	45	45	44	44
		S9	48,000	45	44	44	43
2	WV Pav W1-RAP - 8%	S10	48,000	45	44	43	43
		S12	48,000	44	44	42	42
		S13	48,000	45	44	42	43

Table 13: BPN data for Series 3 specimen

Mix No.	Mix Name	Sample Name	Wheel Passes	Trial 1	Trial 2	Trial 3	Trial 4
3	Greer W1H - 4%	S16	0	67	68	68	68
		S26	0	66	66	67	67
		S27	0	64	65	65	66
3	Greer W1H - 8%	S29	0	65	65	66	66
		S30	0	66	68	68	68
		S31	0	67	67	68	67
4	WV Pav 12.5mm SKID - 4%	S20	0	65	65	65	64
		S21	0	63	64	64	64
		S22	0	60	60	61	61
4	WV Pav 12.5mm SKID - 8%	S23	0	64	65	65	66
		S25	0	62	62	62	63
		S32	0	61	61	62	63
3	Greer W1H - 4%	S16	8,000	55	55	53	52
		S26	8,000	54	54	54	53
		S27	8,000	55	54	53	52
3	Greer W1H - 8%	S29	8,000	53	53	52	51
		S30	8,000	53	53	52	53
		S31	8,000	55	54	52	51
4	WV Pav 12.5mm SKID - 4%	S20	8,000	55	54	53	52
		S21	8,000	54	53	53	52
		S22	8,000	54	53	53	52
4	WV Pav 12.5mm SKID - 8%	S23	8,000	55	54	54	53
		S25	8,000	54	54	53	53
		S32	8,000	55	54	53	53
3	Greer W1H - 4%	S16	16,000	49	48	47	47
		S26	16,000	48	46	46	46
		S27	16,000	48	47	47	47
3	Greer W1H - 8%	S29	16,000	48	47	47	46
		S30	16,000	48	47	46	46
		S31	16,000	49	47	46	47
4	WV Pav 12.5mm SKID - 4%	S20	16,000	48	47	47	46
		S21	16,000	50	49	49	48
		S22	16,000	49	47	48	47
4		S23	16,000	52	51	49	49

	WV Pav 12.5mm SKID - 8%	S25	16,000	51	49	48	48
		S32	16,000	51	51	50	49
3	Greer W1H - 4%	S16	32,000	46	44	44	43
		S26	32,000	46	45	43	43
		S27	32,000	45	44	44	43
3	Greer W1H - 8%	S29	32,000	46	44	43	43
		S30	32,000	47	46	45	45
		S31	32,000	45	43	43	43
4	WV Pav 12.5mm SKID - 4%	S20	32,000	46	45	44	44
		S21	32,000	46	45	44	44
		S22	32,000	45	44	44	44
4	WV Pav 12.5mm SKID - 8%	S23	32,000	47	46	45	45
		S25	32,000	47	45	45	44
		S32	32,000	46	46	45	44
3	Greer W1H - 4%	S16	48,000	41	40	39	38
		S26	48,000	41	40	39	38
		S27	48,000	41	39	38	38
3	Greer W1H - 8%	S29	48,000	40	38	38	36
		S30	48,000	42	39	38	38
		S31	48,000	42	39	38	38
4	WV Pav 12.5mm SKID - 4%	S20	48,000	42	41	39	38
		S21	48,000	42	40	39	39
		S22	48,000	42	39	38	38
4	WV Pav 12.5mm SKID - 8%	S23	48,000	43	41	40	39
		S25	48,000	41	39	37	37
		S32	48,000	42	41	40	39

Table 14: BPN data for Series 4 specimen

Mix No.	Mix Name	Sample Name	Wheel Passes	Trial 1	Trial 2	Trial 3	Trial 4
3	Greer W1H - 4%	S16	0	67	67	67	66
		S26	0	71	70	70	70
		S27	0	72	71	71	70
3	Greer W1H - 8%	S29	0	73	74	74	72
		S30	0	71	70	69	68
		S31	0	72	71	69	69
4	WV Pav 12.5mm SKID - 4%	S20	0	72	70	70	69
		S21	0	72	71	71	71
		S22	0	72	71	71	70
4	WV Pav 12.5mm SKID - 8%	S23	0	73	73	74	72
		S25	0	73	71	71	70
		S32	0	73	73	73	72
3	Greer W1H - 4%	S16	8,000	51	49	48	48
		S26	8,000	49	49	49	48
		S27	8,000	51	50	50	50
3	Greer W1H - 8%	S29	8,000	51	50	50	50
		S30	8,000	52	51	51	50
		S31	8,000	52	51	50	50
4	WV Pav 12.5mm SKID - 4%	S20	8,000	53	51	51	50
		S21	8,000	54	54	53	52
		S22	8,000	55	54	53	53
4	WV Pav 12.5mm SKID - 8%	S23	8,000	55	54	53	53
		S25	8,000	53	53	52	51
		S32	8,000	53	52	51	51
3	Greer W1H - 4%	S16	16,000	45	44	45	44
		S26	16,000	46	45	45	44
		S27	16,000	45	44	43	43
3	Greer W1H - 8%	S29	16,000	47	45	45	45
		S30	16,000	48	46	46	45
		S31	16,000	46	45	44	45
4	WV Pav 12.5mm SKID - 4%	S20	16,000	48	48	47	46
		S21	16,000	51	50	49	49
		S22	16,000	51	49	49	48
4		S23	16,000	52	51	49	49

	WV Pav 12.5mm SKID - 8%	S25	16,000	49	48	47	47
		S32	16,000	50	48	47	46
3	Greer W1H - 4%	S16	32,000	42	41	40	39
		S26	32,000	41	40	39	38
		S27	32,000	41	40	40	39
3	Greer W1H - 8%	S29	32,000	43	41	40	40
		S30	32,000	42	41	40	40
		S31	32,000	41	39	38	38
4	WV Pav 12.5mm SKID - 4%	S20	32,000	43	41	40	40
		S21	32,000	44	43	41	42
		S22	32,000	43	41	40	40
4	WV Pav 12.5mm SKID - 8%	S23	32,000	45	45	43	42
		S25	32,000	44	42	42	41
		S32	32,000	44	42	42	41
3	Greer W1H - 4%	S16	48,000	40	39	37	37
		S26	48,000	39	37	36	35
		S27	48,000	40	38	37	36
3	Greer W1H - 8%	S29	48,000	42	40	39	37
		S30	48,000	40	38	37	36
		S31	48,000	40	37	37	36
4	WV Pav 12.5mm SKID - 4%	S20	48,000	42	40	39	39
		S21	48,000	44	41	40	39
		S22	48,000	42	40	39	39
4	WV Pav 12.5mm SKID - 8%	S23	48,000	46	44	41	40
		S25	48,000	44	42	40	39
		S32	48,000	43	41	40	39

Table 15: Data for Original and Replicate Statistical Comparison

		Original Sample No.	BPN_{Original}	Replicate Sample No.	BPN_{Replicate}
Sample Bottoms Low Toe	JFA 12.5mm SR 4% VTM	25	47.5	S1	38.5
		26	47.25	S2	37.75
		27	48.75	S3	38.75
	JFA 12.5mm SR 8% VTM	28	49.75	S4	39.25
		29	49	S5	39.5
		30	49.25	S6	39.25
	WVP W1- RAP 4% VTM	31	50.75	S7	42.5
		32	48.75	S8	44.5
		33	50.5	S9	44
	WVP W1- RAP 8% VTM	34	50.75	S10	43.75
		35	50.25	S12	43
		36	48.75	S13	43.5
	WVP 12.5mm SR 4% VTM	19	45.5	S20	40
		20	47.5	S21	40
		21	44.25	S22	39.25
	WVP 12.5mm SR 8% VTM	22	43.75	S23	40.75
		23	43.5	S25	38.5
		24	45.75	S32	40.5
	Greer W1H 4% VTM	16	43	S16	39.5
		17	42.75	S26	39.5
		18	43	S27	39
	Greer W1H 8% VTM	13	43.75	S29	38
		14	42.5	S30	39.25
		15	43.75	S31	39.25
Sample Tops High Toe	JFA 12.5mm SR 4% VTM	25	40.25	S1	41.5
		26	40	S2	39.75
		27	41	S3	41.75
	JFA 12.5mm SR 8% VTM	28	40.5	S4	40.25
		29	41.75	S5	39
		30	40.5	S6	41.25
	WVP W1- RAP 4% VTM	31	40.5	S7	44.75
		32	40.75	S8	43.5
		33	41.5	S9	42.5
	WVP W1- RAP 8% VTM	34	41.5	S10	43
		35	41	S12	43
		36	40	S13	43.75

	WVP 12.5mm SR 4% VTM	19	46.25	S20	40
		20	45.75	S21	41
		21	47.75	S22	40
	WVP 12.5mm SR 8% VTM	22	47.5	S23	42.75
		23	46.25	S25	41.25
		24	47	S32	40.75
	Greer W1H 4% VTM	16	44.5	S16	38.25
		17	43.25	S26	36.75
		18	42.75	S27	37.75
	Greer W1H 8% VTM	13	43	S29	39.5
		14	43.5	S30	37.75
		15	44.75	S31	37.5

Table 16: Comparison of Average BPN After 48,000 Wheel Passes at 4% VTM, High Toe

	Average BPN			
	Mix 1 12.5mm Skid-RAP	Mix 2 W1-RAP	Mix 3 W1H	Mix 4 12.5mm Skid-RAP
Original Experiment	40	41	44	47
Replicate Experiment	41	44	38	40

Table 17: Comparison of Average BPN After 48,000 Wheel Passes at 8% VTM, High Toe

	Average BPN			
	Mix 1 12.5mm Skid-RAP	Mix 2 W1-RAP	Mix 3 W1H	Mix 4 12.5mm Skid-RAP
Original Experiment	41	41	44	47
Replicate Experiment	40	44	38	42

Table 18: Comparison of Average BPN After 48,000 Wheel Passes at 4% VTM, Low Toe

	Average BPN			
	Mix 1 12.5mm Skid-RAP	Mix 2 W1-RAP	Mix 3 W1H	Mix 4 12.5mm Skid-RAP
Original Experiment	48	50	43	46
Replicate Experiment	38	44	39	40

Table 19: Comparison of Average BPN After 48,000 Wheel Passes at 8% VTM, Low Toe

	Average BPN			
	Mix 1 12.5mm Skid-RAP	Mix 2 W1-RAP	Mix 3 W1H	Mix 4 12.5mm Skid-RAP
Original Experiment	49	50	43	44
Replicate Experiment	39	43	39	40

Appendix C: Skid Resistant Asphalt Experiment Data

Table 20: BPN data for specimen using High Toe

Mix No.	Mix Name	Sample No.	Wheel Passes	Trial 1	Trial 2	Trial 3	Trial 4
1	Per Design	1	0	77	77	76	76
		2	0	74	74	74	74
		3	0	75	74	74	73
2	Opposite Skid	1	0	81	81	80	80
		2	0	78	79	77	77
		3	0	76	77	78	77
3	No Skid	1	0	74	74	73	74
		2	0	76	77	76	76
		3	0	75	75	75	75
4	All Skid	1	0	79	79	78	77
		2	0	75	75	76	74
		3	0	79	78	79	77
1	Per Design	1	8,000	58	56	55	55
		2	8,000	58	56	56	55
		3	8,000	58	56	55	55
2	Opposite Skid	1	8,000	61	59	58	56
		2	8,000	58	56	56	56
		3	8,000	56	56	55	55
3	No Skid	1	8,000	56	55	54	54
		2	8,000	58	57	55	55
		3	8,000	57	57	56	55
4	All Skid	1	8,000	59	58	57	57
		2	8,000	57	55	55	54
		3	8,000	58	56	55	55
1	Per Design	1	16,000	52	50	50	50
		2	16,000	53	52	52	52
		3	16,000	53	51	51	51
2	Opposite Skid	1	16,000	54	52	52	52
		2	16,000	52	51	51	51
		3	16,000	52	51	51	50
3	No Skid	1	16,000	51	51	50	51
		2	16,000	53	51	51	49
		3	16,000	52	50	50	49

4	All Skid	1	16,000	52	52	51	50
		2	16,000	52	52	51	50
		3	16,000	52	52	51	51
1	Per Design	1	32,000	51	50	48	47
		2	32,000	52	50	49	49
		3	32,000	50	49	48	47
2	Opposite Skid	1	32,000	51	50	49	49
		2	32,000	51	51	51	49
		3	32,000	51	50	48	47
3	No Skid	1	32,000	50	48	47	46
		2	32,000	51	50	49	48
		3	32,000	50	50	48	47
4	All Skid	1	32,000	51	50	48	48
		2	32,000	51	49	48	47
		3	32,000	51	50	49	49
1	Per Design	1	48,000	46	45	44	43
		2	48,000	48	46	45	44
		3	48,000	48	46	46	44
2	Opposite Skid	1	48,000	48	46	45	44
		2	48,000	48	46	45	44
		3	48,000	48	46	44	43
3	No Skid	1	48,000	46	44	44	42
		2	48,000	47	45	44	43
		3	48,000	46	45	44	43
4	All Skid	1	48,000	47	46	44	43
		2	48,000	47	45	44	43
		3	48,000	48	46	45	44
1	Per Design	1	80,000	46	44	44	43
		2	80,000	47	45	43	42
		3	80,000	45	44	43	42
2	Opposite Skid	1	80,000	47	45	44	42
		2	80,000	45	44	44	42
		3	80,000	46	44	44	41
3	No Skid	1	80,000	44	42	42	40
		2	80,000	45	44	41	41
		3	80,000	46	44	43	42
4	All Skid	1	80,000	46	44	44	42
		2	80,000	45	43	42	41
		3	80,000	46	44	41	42

Table 21: BPN data for specimen using Low Toe

Mix No.	Mix Name	Sample No.	Wheel Passes	Trial 1	Trial 2	Trial 3	Trial 4
1	Per Design	1	0	68	67	66	66
		2	0	71	70	69	69
		3	0	71	71	71	71
2	Opposite Skid	1	0	74	73	74	74
		2	0	72	72	71	71
		3	0	75	75	74	74
3	No Skid	1	0	71	70	70	70
		2	0	70	69	69	69
		3	0	74	73	72	72
4	All Skid	1	0	76	74	74	74
		2	0	74	73	73	72
		3	0	73	72	74	72
1	Per Design	1	8,000	58	57	57	56
		2	8,000	60	58	57	57
		3	8,000	56	56	56	55
2	Opposite Skid	1	8,000	59	58	56	57
		2	8,000	59	59	57	57
		3	8,000	56	56	56	56
3	No Skid	1	8,000	56	55	55	54
		2	8,000	58	57	57	56
		3	8,000	58	57	56	56
4	All Skid	1	8,000	59	58	57	57
		2	8,000	59	58	57	56
		3	8,000	57	56	55	55
1	Per Design	1	16,000	55	54	53	53
		2	16,000	52	51	51	51
		3	16,000	54	54	54	52
2	Opposite Skid	1	16,000	54	55	54	54
		2	16,000	54	54	54	55
		3	16,000	55	54	53	52
3	No Skid	1	16,000	54	53	52	52
		2	16,000	53	52	51	50
		3	16,000	54	53	52	52
4	All Skid	1	16,000	55	55	54	54
		2	16,000	53	53	53	52

		3	16,000	54	54	52	52
1	Per Design	1	32,000	52	51	50	50
		2	32,000	54	52	51	50
		3	32,000	53	52	51	50
2	Opposite Skid	1	32,000	53	52	50	50
		2	32,000	53	51	50	50
		3	32,000	52	51	50	49
3	No Skid	1	32,000	48	46	47	46
		2	32,000	51	50	49	49
		3	32,000	52	49	49	48
4	All Skid	1	32,000	53	50	50	49
		2	32,000	52	50	50	49
		3	32,000	52	51	50	49
1	Per Design	1	48,000	46	45	44	44
		2	48,000	46	44	43	42
		3	48,000	48	46	45	44
2	Opposite Skid	1	48,000	47	46	45	44
		2	48,000	46	45	44	43
		3	48,000	47	45	44	43
3	No Skid	1	48,000	45	43	42	41
		2	48,000	45	44	44	43
		3	48,000	47	45	44	43
4	All Skid	1	48,000	48	47	44	44
		2	48,000	45	45	43	41
		3	48,000	46	44	44	42
1	Per Design	1	80,000	45	45	44	43
		2	80,000	45	44	43	41
		3	80,000	47	45	45	44
2	Opposite Skid	1	80,000	49	46	45	44
		2	80,000	46	46	45	43
		3	80,000	46	44	43	42
3	No Skid	1	80,000	45	43	41	41
		2	80,000	46	45	44	43
		3	80,000	44	43	43	42
4	All Skid	1	80,000	48	45	44	43
		2	80,000	45	43	41	41
		3	80,000	46	45	43	42

Table 22: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with High Toe

Average BPN				
Wheel Passes	0%	40%	59%	99%
0	75.0	74.8	78.4	77.2
8000	55.8	56.1	56.8	56.3
16000	50.7	54.4	54.6	51.3
32000	48.7	49.2	49.8	49.3
48000	44.4	45.4	45.6	45.2
80000	42.8	44.0	44.0	43.3

Table 23: Average BPN Numbers for 9.5 mm SKID Study at 7% VTM with Low Toe

Average BPN				
Wheel Passes	0%	40%	59%	99%
0	70.8	69.2	73.3	73.4
8000	56.3	56.9	57.2	57.0
16000	52.3	52.8	54.0	53.4
32000	48.7	51.3	50.9	50.4
48000	43.8	44.8	44.9	44.4
80000	43.3	44.3	44.9	43.8

Table 24: Skid Aggregate Content vs Average BPN

Mixture	Skid Aggregate, %	High Toe Average BPN	Low Toe Average BPN
All Skid	99	43.3	43.8
Opposite Skid	59	44.0	44.9
Per Design	40	44.0	44.3
No Skid	0	42.8	43.3

Appendix D: Insoluble Residue Data

Asphalt Burn-off

<p>Elapsed Time: 46:00 Sample Weight: 1529g Weight Loss: 95.5g Percent Loss: 6.25% Temp Comp: 0.20% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.23%</p> <p>Calibrated Asphalt Cnt 5.81% 5.96%</p> <table> <tr><td>46</td><td>538</td><td>95.5</td><td>6.25*</td></tr> <tr><td>45</td><td>538</td><td>95.5</td><td>6.25</td></tr> <tr><td>44</td><td>538</td><td>95.4</td><td>6.24</td></tr> <tr><td>43</td><td>538</td><td>95.3</td><td>6.23</td></tr> <tr><td>42</td><td>538</td><td>95.2</td><td>6.23</td></tr> <tr><td>41</td><td>538</td><td>95.1</td><td>6.22</td></tr> <tr><td>40</td><td>538</td><td>94.9</td><td>6.21</td></tr> <tr><td>39</td><td>538</td><td>94.7</td><td>6.19</td></tr> <tr><td>38</td><td>538</td><td>94.4</td><td>6.17</td></tr> <tr><td>37</td><td>537</td><td>94.1</td><td>6.15</td></tr> <tr><td>36</td><td>536</td><td>93.7</td><td>6.13</td></tr> <tr><td>35</td><td>537</td><td>93.2</td><td>6.10</td></tr> <tr><td>34</td><td>538</td><td>92.7</td><td>6.06</td></tr> <tr><td>33</td><td>540</td><td>92.0</td><td>6.02</td></tr> <tr><td>32</td><td>542</td><td>91.4</td><td>5.98</td></tr> <tr><td>31</td><td>543</td><td>90.8</td><td>5.93</td></tr> <tr><td>30</td><td>545</td><td>89.7</td><td>5.87</td></tr> <tr><td>29</td><td>547</td><td>88.8</td><td>5.81</td></tr> <tr><td>28</td><td>548</td><td>87.8</td><td>5.74</td></tr> <tr><td>27</td><td>549</td><td>86.7</td><td>5.67</td></tr> <tr><td>26</td><td>551</td><td>85.4</td><td>5.59</td></tr> <tr><td>25</td><td>552</td><td>84.1</td><td>5.50</td></tr> <tr><td>24</td><td>552</td><td>82.7</td><td>5.41</td></tr> <tr><td>23</td><td>553</td><td>81.1</td><td>5.30</td></tr> <tr><td>22</td><td>553</td><td>79.5</td><td>5.20</td></tr> <tr><td>21</td><td>553</td><td>78.0</td><td>5.10</td></tr> <tr><td>20</td><td>554</td><td>76.4</td><td>5.00</td></tr> <tr><td>19</td><td>555</td><td>75.0</td><td>4.91</td></tr> <tr><td>18</td><td>556</td><td>73.8</td><td>4.83</td></tr> <tr><td>17</td><td>552</td><td>72.3</td><td>4.73</td></tr> <tr><td>16</td><td>550</td><td>71.7</td><td>4.69</td></tr> <tr><td>15</td><td>548</td><td>70.5</td><td>4.61</td></tr> <tr><td>14</td><td>546</td><td>68.3</td><td>4.47</td></tr> <tr><td>13</td><td>544</td><td>64.6</td><td>4.22</td></tr> <tr><td>12</td><td>543</td><td>58.8</td><td>3.85</td></tr> <tr><td>11</td><td>542</td><td>50.5</td><td>3.30</td></tr> <tr><td>10</td><td>542</td><td>40.5</td><td>2.65</td></tr> <tr><td>9</td><td>546</td><td>30.3</td><td>1.98</td></tr> <tr><td>8</td><td>553</td><td>21.2</td><td>1.39</td></tr> <tr><td>7</td><td>540</td><td>13.4</td><td>0.88</td></tr> <tr><td>6</td><td>485</td><td>7.8</td><td>0.51</td></tr> <tr><td>5</td><td>477</td><td>4.4</td><td>0.29</td></tr> <tr><td>4</td><td>469</td><td>3.0</td><td>0.20</td></tr> <tr><td>3</td><td>459</td><td>2.0</td><td>0.13</td></tr> <tr><td>2</td><td>450</td><td>1.2</td><td>0.08</td></tr> <tr><td>1</td><td>446</td><td>0.6</td><td>0.04</td></tr> </table> <p>T TEMP WT.LOSS XLOSS</p> <p>Filter Set Pt: 750 C Chamber Set Pt: 538 C</p> <p>Tested By:</p> <p>Mix Type: <u>All Skid #1</u></p> <p>Sample ID:</p> <p>Time: 9:26:52 Date: 02-27-20</p>	46	538	95.5	6.25*	45	538	95.5	6.25	44	538	95.4	6.24	43	538	95.3	6.23	42	538	95.2	6.23	41	538	95.1	6.22	40	538	94.9	6.21	39	538	94.7	6.19	38	538	94.4	6.17	37	537	94.1	6.15	36	536	93.7	6.13	35	537	93.2	6.10	34	538	92.7	6.06	33	540	92.0	6.02	32	542	91.4	5.98	31	543	90.8	5.93	30	545	89.7	5.87	29	547	88.8	5.81	28	548	87.8	5.74	27	549	86.7	5.67	26	551	85.4	5.59	25	552	84.1	5.50	24	552	82.7	5.41	23	553	81.1	5.30	22	553	79.5	5.20	21	553	78.0	5.10	20	554	76.4	5.00	19	555	75.0	4.91	18	556	73.8	4.83	17	552	72.3	4.73	16	550	71.7	4.69	15	548	70.5	4.61	14	546	68.3	4.47	13	544	64.6	4.22	12	543	58.8	3.85	11	542	50.5	3.30	10	542	40.5	2.65	9	546	30.3	1.98	8	553	21.2	1.39	7	540	13.4	0.88	6	485	7.8	0.51	5	477	4.4	0.29	4	469	3.0	0.20	3	459	2.0	0.13	2	450	1.2	0.08	1	446	0.6	0.04	<p>Elapsed Time: 47:00 Sample Weight: 1531g Weight Loss: 94.6g Percent Loss: 6.18% Temp Comp: 0.18% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.17%</p> <p>Calibrated Asphalt Cnt 5.76% 5.91%</p> <table> <tr><td>47</td><td>538</td><td>94.6</td><td>6.18*</td></tr> <tr><td>46</td><td>538</td><td>94.6</td><td>6.18</td></tr> <tr><td>45</td><td>538</td><td>94.5</td><td>6.17</td></tr> <tr><td>44</td><td>538</td><td>94.4</td><td>6.17</td></tr> <tr><td>43</td><td>537</td><td>94.2</td><td>6.15</td></tr> <tr><td>42</td><td>537</td><td>93.9</td><td>6.13</td></tr> <tr><td>41</td><td>537</td><td>93.6</td><td>6.11</td></tr> <tr><td>40</td><td>537</td><td>93.4</td><td>6.10</td></tr> <tr><td>39</td><td>537</td><td>93.0</td><td>6.07</td></tr> <tr><td>38</td><td>539</td><td>92.8</td><td>6.05</td></tr> <tr><td>37</td><td>541</td><td>92.1</td><td>6.02</td></tr> <tr><td>36</td><td>543</td><td>91.5</td><td>5.98</td></tr> <tr><td>35</td><td>545</td><td>90.8</td><td>5.93</td></tr> <tr><td>34</td><td>547</td><td>90.0</td><td>5.88</td></tr> <tr><td>33</td><td>548</td><td>89.3</td><td>5.83</td></tr> <tr><td>32</td><td>550</td><td>88.4</td><td>5.77</td></tr> <tr><td>31</td><td>552</td><td>87.4</td><td>5.71</td></tr> <tr><td>30</td><td>553</td><td>86.2</td><td>5.63</td></tr> <tr><td>29</td><td>555</td><td>85.0</td><td>5.55</td></tr> <tr><td>28</td><td>556</td><td>83.8</td><td>5.47</td></tr> <tr><td>27</td><td>557</td><td>82.5</td><td>5.39</td></tr> <tr><td>26</td><td>557</td><td>81.1</td><td>5.30</td></tr> <tr><td>25</td><td>558</td><td>79.6</td><td>5.20</td></tr> <tr><td>24</td><td>558</td><td>78.0</td><td>5.09</td></tr> <tr><td>23</td><td>559</td><td>76.4</td><td>4.99</td></tr> <tr><td>22</td><td>560</td><td>75.0</td><td>4.90</td></tr> <tr><td>21</td><td>559</td><td>73.8</td><td>4.82</td></tr> <tr><td>20</td><td>556</td><td>72.8</td><td>4.76</td></tr> <tr><td>19</td><td>554</td><td>72.3</td><td>4.72</td></tr> <tr><td>18</td><td>553</td><td>71.6</td><td>4.68</td></tr> <tr><td>17</td><td>551</td><td>70.4</td><td>4.60</td></tr> <tr><td>16</td><td>550</td><td>68.5</td><td>4.47</td></tr> <tr><td>15</td><td>549</td><td>66.0</td><td>4.31</td></tr> <tr><td>14</td><td>548</td><td>62.7</td><td>4.10</td></tr> <tr><td>13</td><td>547</td><td>58.8</td><td>3.84</td></tr> <tr><td>12</td><td>547</td><td>54.3</td><td>3.55</td></tr> <tr><td>11</td><td>545</td><td>49.1</td><td>3.21</td></tr> <tr><td>10</td><td>544</td><td>43.1</td><td>2.82</td></tr> <tr><td>9</td><td>543</td><td>36.2</td><td>2.36</td></tr> <tr><td>8</td><td>545</td><td>28.6</td><td>1.87</td></tr> <tr><td>7</td><td>551</td><td>20.4</td><td>1.33</td></tr> <tr><td>6</td><td>554</td><td>13.1</td><td>0.86</td></tr> <tr><td>5</td><td>488</td><td>7.0</td><td>0.46</td></tr> <tr><td>4</td><td>475</td><td>3.2</td><td>0.21</td></tr> <tr><td>3</td><td>464</td><td>1.9</td><td>0.12</td></tr> <tr><td>2</td><td>453</td><td>1.1</td><td>0.07</td></tr> <tr><td>1</td><td>448</td><td>0.6</td><td>0.04</td></tr> </table> <p>T TEMP WT.LOSS XLOSS</p> <p>Filter Set Pt: 750 C Chamber Set Pt: 538 C</p> <p>Tested By:</p> <p>Mix Type: <u>All Skid #2</u></p> <p>Sample ID:</p> <p>Time: 10:18:35 Date: 02-27-20</p>	47	538	94.6	6.18*	46	538	94.6	6.18	45	538	94.5	6.17	44	538	94.4	6.17	43	537	94.2	6.15	42	537	93.9	6.13	41	537	93.6	6.11	40	537	93.4	6.10	39	537	93.0	6.07	38	539	92.8	6.05	37	541	92.1	6.02	36	543	91.5	5.98	35	545	90.8	5.93	34	547	90.0	5.88	33	548	89.3	5.83	32	550	88.4	5.77	31	552	87.4	5.71	30	553	86.2	5.63	29	555	85.0	5.55	28	556	83.8	5.47	27	557	82.5	5.39	26	557	81.1	5.30	25	558	79.6	5.20	24	558	78.0	5.09	23	559	76.4	4.99	22	560	75.0	4.90	21	559	73.8	4.82	20	556	72.8	4.76	19	554	72.3	4.72	18	553	71.6	4.68	17	551	70.4	4.60	16	550	68.5	4.47	15	549	66.0	4.31	14	548	62.7	4.10	13	547	58.8	3.84	12	547	54.3	3.55	11	545	49.1	3.21	10	544	43.1	2.82	9	543	36.2	2.36	8	545	28.6	1.87	7	551	20.4	1.33	6	554	13.1	0.86	5	488	7.0	0.46	4	475	3.2	0.21	3	464	1.9	0.12	2	453	1.1	0.07	1	448	0.6	0.04	<p>Elapsed Time: 48:00 Sample Weight: 1593g Weight Loss: 99.8g Percent Loss: 6.25% Temp Comp: 0.17% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.26%</p> <p>Calibrated Asphalt Cnt 5.84% 5.99%</p> <table> <tr><td>48</td><td>536</td><td>99.8</td><td>6.25*</td></tr> <tr><td>47</td><td>536</td><td>99.8</td><td>6.25</td></tr> <tr><td>46</td><td>537</td><td>99.5</td><td>6.25</td></tr> <tr><td>45</td><td>539</td><td>99.2</td><td>6.23</td></tr> <tr><td>44</td><td>541</td><td>98.9</td><td>6.21</td></tr> <tr><td>43</td><td>543</td><td>98.6</td><td>6.19</td></tr> <tr><td>42</td><td>545</td><td>98.2</td><td>6.16</td></tr> <tr><td>41</td><td>547</td><td>97.7</td><td>6.13</td></tr> <tr><td>40</td><td>549</td><td>97.0</td><td>6.09</td></tr> <tr><td>39</td><td>551</td><td>96.4</td><td>6.05</td></tr> <tr><td>38</td><td>552</td><td>95.6</td><td>6.00</td></tr> <tr><td>37</td><td>554</td><td>94.8</td><td>5.95</td></tr> <tr><td>36</td><td>556</td><td>93.9</td><td>5.89</td></tr> <tr><td>35</td><td>557</td><td>93.0</td><td>5.84</td></tr> <tr><td>34</td><td>559</td><td>91.9</td><td>5.77</td></tr> <tr><td>33</td><td>560</td><td>90.7</td><td>5.69</td></tr> <tr><td>32</td><td>561</td><td>89.4</td><td>5.61</td></tr> <tr><td>31</td><td>563</td><td>88.1</td><td>5.53</td></tr> <tr><td>30</td><td>564</td><td>86.7</td><td>5.44</td></tr> <tr><td>29</td><td>565</td><td>85.1</td><td>5.34</td></tr> <tr><td>28</td><td>567</td><td>83.5</td><td>5.24</td></tr> <tr><td>27</td><td>568</td><td>81.9</td><td>5.14</td></tr> <tr><td>26</td><td>569</td><td>80.2</td><td>5.03</td></tr> <tr><td>25</td><td>570</td><td>78.6</td><td>4.93</td></tr> <tr><td>24</td><td>567</td><td>77.2</td><td>4.85</td></tr> <tr><td>23</td><td>561</td><td>76.1</td><td>4.78</td></tr> <tr><td>22</td><td>559</td><td>75.8</td><td>4.76</td></tr> <tr><td>21</td><td>557</td><td>75.5</td><td>4.74</td></tr> <tr><td>20</td><td>556</td><td>75.2</td><td>4.72</td></tr> <tr><td>19</td><td>554</td><td>74.7</td><td>4.69</td></tr> <tr><td>18</td><td>552</td><td>73.9</td><td>4.64</td></tr> <tr><td>17</td><td>550</td><td>72.7</td><td>4.56</td></tr> <tr><td>16</td><td>548</td><td>70.7</td><td>4.44</td></tr> <tr><td>15</td><td>546</td><td>67.8</td><td>4.26</td></tr> <tr><td>14</td><td>544</td><td>64.0</td><td>4.02</td></tr> <tr><td>13</td><td>542</td><td>59.4</td><td>3.73</td></tr> <tr><td>12</td><td>540</td><td>54.3</td><td>3.41</td></tr> <tr><td>11</td><td>537</td><td>48.9</td><td>3.07</td></tr> <tr><td>10</td><td>535</td><td>42.7</td><td>2.68</td></tr> <tr><td>9</td><td>536</td><td>35.2</td><td>2.21</td></tr> <tr><td>8</td><td>544</td><td>26.6</td><td>1.67</td></tr> <tr><td>7</td><td>560</td><td>17.8</td><td>1.12</td></tr> <tr><td>6</td><td>519</td><td>10.8</td><td>0.68</td></tr> <tr><td>5</td><td>481</td><td>5.9</td><td>0.37</td></tr> <tr><td>4</td><td>470</td><td>3.1</td><td>0.19</td></tr> <tr><td>3</td><td>459</td><td>2.0</td><td>0.13</td></tr> <tr><td>2</td><td>450</td><td>1.1</td><td>0.07</td></tr> <tr><td>1</td><td>445</td><td>0.6</td><td>0.04</td></tr> </table> <p>T TEMP WT.LOSS XLOSS</p> <p>Filter Set Pt: 750 C Chamber Set Pt: 538 C</p> <p>Tested By:</p> <p>Mix Type: <u>Opposite #1</u></p> <p>Sample ID:</p> <p>Time: 12:55:52 Date: 02-27-20</p>	48	536	99.8	6.25*	47	536	99.8	6.25	46	537	99.5	6.25	45	539	99.2	6.23	44	541	98.9	6.21	43	543	98.6	6.19	42	545	98.2	6.16	41	547	97.7	6.13	40	549	97.0	6.09	39	551	96.4	6.05	38	552	95.6	6.00	37	554	94.8	5.95	36	556	93.9	5.89	35	557	93.0	5.84	34	559	91.9	5.77	33	560	90.7	5.69	32	561	89.4	5.61	31	563	88.1	5.53	30	564	86.7	5.44	29	565	85.1	5.34	28	567	83.5	5.24	27	568	81.9	5.14	26	569	80.2	5.03	25	570	78.6	4.93	24	567	77.2	4.85	23	561	76.1	4.78	22	559	75.8	4.76	21	557	75.5	4.74	20	556	75.2	4.72	19	554	74.7	4.69	18	552	73.9	4.64	17	550	72.7	4.56	16	548	70.7	4.44	15	546	67.8	4.26	14	544	64.0	4.02	13	542	59.4	3.73	12	540	54.3	3.41	11	537	48.9	3.07	10	535	42.7	2.68	9	536	35.2	2.21	8	544	26.6	1.67	7	560	17.8	1.12	6	519	10.8	0.68	5	481	5.9	0.37	4	470	3.1	0.19	3	459	2.0	0.13	2	450	1.1	0.07	1	445	0.6	0.04	<p>Elapsed Time: 54:00 Sample Weight: 1651g Weight Loss: 103.5g Percent Loss: 6.27% Temp Comp: 0.18% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.27%</p> <p>Calibrated Asphalt Cnt 5.85% 6.00%</p> <table> <tr><td>54</td><td>538</td><td>103.5</td><td>6.27*</td></tr> <tr><td>53</td><td>538</td><td>103.5</td><td>6.27</td></tr> <tr><td>52</td><td>538</td><td>103.4</td><td>6.26</td></tr> <tr><td>51</td><td>539</td><td>103.3</td><td>6.26</td></tr> <tr><td>50</td><td>538</td><td>103.2</td><td>6.25</td></tr> <tr><td>49</td><td>537</td><td>103.1</td><td>6.24</td></tr> <tr><td>48</td><td>537</td><td>102.9</td><td>6.23</td></tr> <tr><td>47</td><td>536</td><td>102.7</td><td>6.22</td></tr> <tr><td>46</td><td>537</td><td>102.4</td><td>6.20</td></tr> <tr><td>45</td><td>538</td><td>102.1</td><td>6.18</td></tr> <tr><td>44</td><td>540</td><td>101.8</td><td>6.17</td></tr> <tr><td>43</td><td>542</td><td>101.3</td><td>6.14</td></tr> <tr><td>42</td><td>544</td><td>100.9</td><td>6.11</td></tr> <tr><td>41</td><td>546</td><td>100.3</td><td>6.08</td></tr> <tr><td>40</td><td>548</td><td>99.7</td><td>6.04</td></tr> <tr><td>39</td><td>551</td><td>99.1</td><td>6.00</td></tr> <tr><td>38</td><td>552</td><td>98.4</td><td>5.96</td></tr> <tr><td>37</td><td>554</td><td>97.6</td><td>5.91</td></tr> <tr><td>36</td><td>556</td><td>96.7</td><td>5.86</td></tr> <tr><td>35</td><td>557</td><td>95.6</td><td>5.79</td></tr> <tr><td>34</td><td>559</td><td>94.5</td><td>5.72</td></tr> <tr><td>33</td><td>560</td><td>93.3</td><td>5.65</td></tr> <tr><td>32</td><td>561</td><td>92.0</td><td>5.57</td></tr> <tr><td>31</td><td>563</td><td>90.6</td><td>5.49</td></tr> <tr><td>30</td><td>564</td><td>89.1</td><td>5.40</td></tr> <tr><td>29</td><td>565</td><td>87.5</td><td>5.30</td></tr> <tr><td>28</td><td>566</td><td>85.9</td><td>5.20</td></tr> <tr><td>27</td><td>567</td><td>84.2</td><td>5.10</td></tr> <tr><td>26</td><td>568</td><td>82.6</td><td>5.00</td></tr> <tr><td>25</td><td>568</td><td>81.0</td><td>4.91</td></tr> <tr><td>24</td><td>565</td><td>79.6</td><td>4.82</td></tr> <tr><td>23</td><td>560</td><td>78.7</td><td>4.77</td></tr> <tr><td>22</td><td>558</td><td>78.4</td><td>4.75</td></tr> <tr><td>21</td><td>556</td><td>78.1</td><td>4.73</td></tr> <tr><td>20</td><td>555</td><td>77.8</td><td>4.71</td></tr> <tr><td>19</td><td>553</td><td>77.4</td><td>4.69</td></tr> <tr><td>18</td><td>551</td><td>76.8</td><td>4.65</td></tr> <tr><td>17</td><td>549</td><td>75.8</td><td>4.59</td></tr> <tr><td>16</td><td>547</td><td>74.2</td><td>4.49</td></tr> <tr><td>15</td><td>545</td><td>71.7</td><td>4.34</td></tr> <tr><td>14</td><td>543</td><td>67.9</td><td>4.11</td></tr> <tr><td>13</td><td>541</td><td>62.4</td><td>3.78</td></tr> <tr><td>12</td><td>539</td><td>55.3</td><td>3.35</td></tr> <tr><td>11</td><td>536</td><td>47.3</td><td>2.86</td></tr> <tr><td>10</td><td>536</td><td>39.2</td><td>2.37</td></tr> <tr><td>9</td><td>539</td><td>31.3</td><td>1.90</td></tr> <tr><td>8</td><td>548</td><td>23.5</td><td>1.42</td></tr> <tr><td>7</td><td>556</td><td>16.0</td><td>0.97</td></tr> <tr><td>6</td><td>501</td><td>9.6</td><td>0.58</td></tr> <tr><td>5</td><td>481</td><td>5.2</td><td>0.31</td></tr> <tr><td>4</td><td>471</td><td>3.2</td><td>0.19</td></tr> <tr><td>3</td><td>462</td><td>2.0</td><td>0.12</td></tr> <tr><td>2</td><td>450</td><td>1.2</td><td>0.07</td></tr> <tr><td>1</td><td>445</td><td>0.7</td><td>0.04</td></tr> </table> <p>T TEMP WT.LOSS XLOSS</p> <p>Filter Set Pt: 750 C Chamber Set Pt: 538 C</p> <p>Tested By:</p> <p>Mix Type: <u>Opposite #2</u></p> <p>Sample ID:</p> <p>Time: 13:50:07 Date: 02-27-20</p>	54	538	103.5	6.27*	53	538	103.5	6.27	52	538	103.4	6.26	51	539	103.3	6.26	50	538	103.2	6.25	49	537	103.1	6.24	48	537	102.9	6.23	47	536	102.7	6.22	46	537	102.4	6.20	45	538	102.1	6.18	44	540	101.8	6.17	43	542	101.3	6.14	42	544	100.9	6.11	41	546	100.3	6.08	40	548	99.7	6.04	39	551	99.1	6.00	38	552	98.4	5.96	37	554	97.6	5.91	36	556	96.7	5.86	35	557	95.6	5.79	34	559	94.5	5.72	33	560	93.3	5.65	32	561	92.0	5.57	31	563	90.6	5.49	30	564	89.1	5.40	29	565	87.5	5.30	28	566	85.9	5.20	27	567	84.2	5.10	26	568	82.6	5.00	25	568	81.0	4.91	24	565	79.6	4.82	23	560	78.7	4.77	22	558	78.4	4.75	21	556	78.1	4.73	20	555	77.8	4.71	19	553	77.4	4.69	18	551	76.8	4.65	17	549	75.8	4.59	16	547	74.2	4.49	15	545	71.7	4.34	14	543	67.9	4.11	13	541	62.4	3.78	12	539	55.3	3.35	11	536	47.3	2.86	10	536	39.2	2.37	9	539	31.3	1.90	8	548	23.5	1.42	7	556	16.0	0.97	6	501	9.6	0.58	5	481	5.2	0.31	4	471	3.2	0.19	3	462	2.0	0.12	2	450	1.2	0.07	1	445	0.7	0.04
46	538	95.5	6.25*																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
45	538	95.5	6.25																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
44	538	95.4	6.24																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
43	538	95.3	6.23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
42	538	95.2	6.23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
41	538	95.1	6.22																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
40	538	94.9	6.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
39	538	94.7	6.19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
38	538	94.4	6.17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
37	537	94.1	6.15																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
36	536	93.7	6.13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
35	537	93.2	6.10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
34	538	92.7	6.06																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
33	540	92.0	6.02																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
32	542	91.4	5.98																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
31	543	90.8	5.93																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
30	545	89.7	5.87																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
29	547	88.8	5.81																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
28	548	87.8	5.74																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
27	549	86.7	5.67																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
26	551	85.4	5.59																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
25	552	84.1	5.50																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
24	552	82.7	5.41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
23	553	81.1	5.30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
22	553	79.5	5.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
21	553	78.0	5.10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
20	554	76.4	5.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
19	555	75.0	4.91																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
18	556	73.8	4.83																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
17	552	72.3	4.73																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
16	550	71.7	4.69																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
15	548	70.5	4.61																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
14	546	68.3	4.47																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
13	544	64.6	4.22																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
12	543	58.8	3.85																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
11	542	50.5	3.30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
10	542	40.5	2.65																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
9	546	30.3	1.98																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
8	553	21.2	1.39																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
7	540	13.4	0.88																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
6	485	7.8	0.51																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
5	477	4.4	0.29																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
4	469	3.0	0.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
3	459	2.0	0.13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
2	450	1.2	0.08																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
1	446	0.6	0.04																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
47	538	94.6	6.18*																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
46	538	94.6	6.18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
45	538	94.5	6.17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
44	538	94.4	6.17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
43	537	94.2	6.15																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
42	537	93.9	6.13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
41	537	93.6	6.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
40	537	93.4	6.10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
39	537	93.0	6.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
38	539	92.8	6.05																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
37	541	92.1	6.02																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
36	543	91.5	5.98																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
35	545	90.8	5.93																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
34	547	90.0	5.88																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
33	548	89.3	5.83																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
32	550	88.4	5.77																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
31	552	87.4	5.71																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
30	553	86.2	5.63																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
29	555	85.0	5.55																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
28	556	83.8	5.47																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
27	557	82.5	5.39																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
26	557	81.1	5.30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
25	558	79.6	5.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
24	558	78.0	5.09																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
23	559	76.4	4.99																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
22	560	75.0	4.90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
21	559	73.8	4.82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
20	556	72.8	4.76																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
19	554	72.3	4.72																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
18	553	71.6	4.68																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
17	551	70.4	4.60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
16	550	68.5	4.47																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
15	549	66.0	4.31																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
14	548	62.7	4.10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
13	547	58.8	3.84																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
12	547	54.3	3.55																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
11	545	49.1	3.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
10	544	43.1	2.82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
9	543	36.2	2.36																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
8	545	28.6	1.87																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
7	551	20.4	1.33																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
6	554	13.1	0.86																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
5	488	7.0	0.46																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
4	475	3.2	0.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
3	464	1.9	0.12																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
2	453	1.1	0.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
1	448	0.6	0.04																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
48	536	99.8	6.25*																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
47	536	99.8	6.25																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
46	537	99.5	6.25																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
45	539	99.2	6.23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
44	541	98.9	6.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
43	543	98.6	6.19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
42	545	98.2	6.16																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
41	547	97.7	6.13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
40	549	97.0	6.09																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
39	551	96.4	6.05																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
38	552	95.6	6.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
37	554	94.8	5.95																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
36	556	93.9	5.89																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
35	557	93.0	5.84																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
34	559	91.9	5.77																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
33	560	90.7	5.69																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
32	561	89.4	5.61																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
31	563	88.1	5.53																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
30	564	86.7	5.44																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
29	565	85.1	5.34																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
28	567	83.5	5.24																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
27	568	81.9	5.14																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
26	569	80.2	5.03																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
25	570	78.6	4.93																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
24	567	77.2	4.85																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
23	561	76.1	4.78																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
22	559	75.8	4.76																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
21	557	75.5	4.74																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
20	556	75.2	4.72																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
19	554	74.7	4.69																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
18	552	73.9	4.64																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
17	550	72.7	4.56																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
16	548	70.7	4.44																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
15	546	67.8	4.26																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
14	544	64.0	4.02																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
13	542	59.4	3.73																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
12	540	54.3	3.41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
11	537	48.9	3.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
10	535	42.7	2.68																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
9	536	35.2	2.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
8	544	26.6	1.67																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
7	560	17.8	1.12																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
6	519	10.8	0.68																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
5	481	5.9	0.37																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
4	470	3.1	0.19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
3	459	2.0	0.13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
2	450	1.1	0.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
1	445	0.6	0.04																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
54	538	103.5	6.27*																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
53	538	103.5	6.27																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
52	538	103.4	6.26																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
51	539	103.3	6.26																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
50	538	103.2	6.25																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
49	537	103.1	6.24																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
48	537	102.9	6.23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
47	536	102.7	6.22																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
46	537	102.4	6.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
45	538	102.1	6.18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
44	540	101.8	6.17																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
43	542	101.3	6.14																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
42	544	100.9	6.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
41	546	100.3	6.08																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
40	548	99.7	6.04																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
39	551	99.1	6.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
38	552	98.4	5.96																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
37	554	97.6	5.91																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
36	556	96.7	5.86																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
35	557	95.6	5.79																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
34	559	94.5	5.72																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
33	560	93.3	5.65																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
32	561	92.0	5.57																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
31	563	90.6	5.49																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
30	564	89.1	5.40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
29	565	87.5	5.30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
28	566	85.9	5.20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
27	567	84.2	5.10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
26	568	82.6	5.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
25	568	81.0	4.91																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
24	565	79.6	4.82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
23	560	78.7	4.77																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
22	558	78.4	4.75																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
21	556	78.1	4.73																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
20	555	77.8	4.71																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
19	553	77.4	4.69																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
18	551	76.8	4.65																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
17	549	75.8	4.59																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
16	547	74.2	4.49																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
15	545	71.7	4.34																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
14	543	67.9	4.11																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
13	541	62.4	3.78																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
12	539	55.3	3.35																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
11	536	47.3	2.86																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
10	536	39.2	2.37																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
9	539	31.3	1.90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
8	548	23.5	1.42																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
7	556	16.0	0.97																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
6	501	9.6	0.58																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
5	481	5.2	0.31																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
4	471	3.2	0.19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
3	462	2.0	0.12																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
2	450	1.2	0.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
1	445	0.7	0.04																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

Figure 27: Binder Burn-off Tickets for All Skid and Opposite Skid

Elapsed Time: 50:00 Sample Weight: 1578g Weight Loss: 98.8g Percent Loss: 6.25% Temp Comp: 0.19% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.23%				Elapsed Time: 50:00 Sample Weight: 1584g Weight Loss: 98.9g Percent Loss: 6.32% Temp Comp: 0.17% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.34%				Elapsed Time: 46:00 Sample Weight: 1517g Weight Loss: 98.7g Percent Loss: 6.51% Temp Comp: 0.19% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.53%				Elapsed Time: 46:00 Sample Weight: 1509g Weight Loss: 98.5g Percent Loss: 6.39% Temp Comp: 0.19% Calib. Factor: 0.24% 0.09 Bitumen Ratio: 6.40%			
Calibrated Asphalt Cnt 5.82% 5.97%				Calibrated Asphalt Cnt 5.91% 6.06%				Calibrated Asphalt Cnt 6.08% 6.23%				Calibrated Asphalt Cnt 5.96% 6.11%			
50	538	98.6	6.25*	50	536	98.9	6.32*	46	536	98.7	6.51*	46	536	98.5	6.39*
49	538	98.6	6.25	49	536	98.9	6.32	45	538	98.7	6.51	45	537	98.4	6.39
48	537	98.5	6.24	48	537	98.8	6.32	44	540	98.6	6.50	44	537	98.4	6.39
47	536	98.4	6.24	47	539	98.7	6.31	43	542	98.4	6.49	43	540	98.2	6.38
46	536	98.3	6.23	46	542	98.5	6.30	42	544	98.2	6.47	42	542	98.0	6.36
45	537	98.2	6.22	45	544	98.3	6.29	41	547	97.9	6.45	41	544	95.6	6.34
44	538	98.0	6.21	44	546	98.0	6.27	40	548	97.6	6.43	40	546	95.3	6.32
43	540	97.8	6.20	43	548	97.7	6.25	39	551	97.2	6.41	39	548	94.8	6.28
42	543	97.5	6.18	42	550	97.3	6.22	38	553	96.8	6.38	38	550	94.3	6.25
41	545	97.0	6.15	41	552	96.8	6.19	37	555	96.3	6.35	37	552	93.7	6.21
40	547	96.6	6.12	40	554	96.2	6.15	36	558	95.7	6.31	36	554	93.0	6.16
39	549	96.1	6.09	39	556	95.6	6.11	35	559	95.1	6.27	35	555	92.3	6.12
38	551	95.6	6.06	38	557	94.9	6.07	34	560	94.4	6.22	34	557	91.4	6.06
37	553	95.0	6.02	37	559	94.2	6.02	33	562	93.5	6.16	33	558	90.4	5.99
36	555	94.2	5.97	36	561	93.4	5.97	32	563	92.7	6.11	32	560	89.3	5.92
35	557	93.4	5.92	35	563	92.5	5.91	31	565	91.6	6.04	31	561	88.2	5.84
34	559	92.6	5.87	34	564	91.4	5.84	30	566	90.5	5.97	30	562	86.8	5.75
33	560	91.5	5.80	33	565	90.3	5.77	29	567	89.2	5.88	29	564	85.5	5.67
32	561	90.4	5.73	32	567	89.2	5.70	28	568	87.9	5.79	28	564	84.0	5.57
31	563	89.2	5.65	31	568	88.0	5.63	27	569	86.4	5.70	27	566	82.4	5.46
30	564	87.8	5.56	30	569	86.6	5.54	26	570	84.7	5.58	26	567	80.8	5.35
29	565	86.3	5.47	29	570	85.1	5.44	25	571	83.0	5.47	25	568	79.0	5.24
28	567	84.8	5.37	28	572	83.6	5.35	24	572	81.1	5.35	24	570	77.2	5.12
27	568	83.1	5.27	27	573	82.0	5.24	23	573	79.1	5.21	23	569	75.5	5.00
26	569	81.3	5.15	26	575	80.3	5.13	22	573	77.2	5.09	22	564	74.0	4.90
25	570	79.5	5.04	25	576	78.6	5.03	21	568	75.4	4.97	21	560	73.3	4.86
24	570	77.8	4.93	24	574	77.1	4.93	20	563	74.5	4.91	20	559	72.9	4.83
23	565	76.1	4.82	23	568	75.7	4.84	19	561	74.1	4.88	19	557	72.5	4.80
22	561	75.3	4.77	22	565	75.3	4.81	18	558	73.7	4.86	18	555	72.0	4.77
21	559	75.0	4.75	21	564	74.9	4.79	17	556	73.1	4.82	17	553	71.3	4.72
20	557	74.7	4.73	20	562	74.5	4.76	16	553	72.4	4.77	16	551	70.0	4.64
19	556	74.3	4.71	19	560	74.1	4.74	15	550	71.2	4.69	15	548	67.9	4.50
18	554	73.9	4.68	18	558	73.5	4.70	14	547	69.2	4.56	14	546	65.0	4.31
17	552	73.3	4.65	17	555	72.6	4.64	13	543	65.9	4.34	13	544	61.1	4.05
16	550	72.2	4.58	16	553	71.1	4.55	12	540	60.8	4.01	12	542	56.4	3.74
15	547	70.4	4.46	15	551	68.8	4.40	11	536	53.6	3.53	11	539	50.8	3.37
14	546	67.7	4.29	14	549	65.6	4.19	10	534	44.8	2.95	10	535	44.3	2.94
13	543	63.5	4.02	13	547	61.5	3.93	9	534	35.7	2.35	9	535	36.8	2.44
12	540	57.9	3.67	12	544	56.6	3.62	8	537	26.7	1.76	8	539	28.4	1.88
11	537	51.1	3.24	11	541	50.8	3.25	7	545	18.3	1.21	7	546	19.3	1.28
10	535	43.7	2.77	10	537	43.9	2.81	6	517	11.5	0.76	6	521	11.8	0.78
9	536	35.6	2.26	9	532	36.0	2.30	5	481	6.2	0.41	5	483	6.3	0.42
8	544	27.1	1.72	8	529	27.1	1.73	4	470	3.3	0.22	4	473	3.4	0.23
7	562	18.5	1.17	7	523	17.7	1.13	3	460	2.1	0.14	3	462	2.1	0.14
6	525	11.4	0.72	6	504	10.4	0.66	2	449	1.2	0.08	2	451	1.2	0.03
5	483	6.3	0.40	5	484	5.7	0.36	1	444	0.7	0.05	1	446	0.6	0.04
4	472	3.3	0.21	4	474	3.1	0.20								
3	462	2.1	0.13	3	464	1.9	0.12								
2	452	1.2	0.08	2	453	1.1	0.07								
1	447	0.6	0.04	1	448	0.6	0.04								

T TEMP WT.LOSS XLOSS				T TEMP WT.LOSS XLOSS				T TEMP WT.LOSS XLOSS				T TEMP WT.LOSS XLOSS			
Filter Set Pt: 750 C Chamber Set Pt: 538 C				Filter Set Pt: 750 C Chamber Set Pt: 538 C				Filter Set Pt: 750 C Chamber Set Pt: 538 C				Filter Set Pt: 750 C Chamber Set Pt: 538 C			
Tested By:				Tested By:				Tested By:				Tested By:			
Mix Type: Per Design #1				Mix Type: Per Design #2				Mix Type: No Skid #1				Mix Type: No Skid #2			
Sample ID:				Sample ID:				Sample ID:				Sample ID:			
Time: 14:49:16				Time: 15:46:29				Time: 11:11:29				Time: 12:02:20			
Date: 02-27-20				Date: 02-27-20				Date: 02-27-20				Date: 02-27-20			

Figure 28: Binder burn-off tickets for Per Design and No Skid

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm All Skid # 1

Technician: Givens / Miller Sample #: 1 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538°C	Data After Ignition	
(A)	Weight of Basket + Sample	4587.6	(D)	Weight of Basket + Aggregate
(B)	Weight of Basket	3058.4	(E)	Weight of Basket
(C)	Sample Weight (A - B)	1529.2	(F)	Aggregate Weight (D - E)
(K)	Percent Asphalt Check: $\{ [(C - F) / C] \times 100 - (\text{Calibration Factor}) \}$			6.0

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	10.2	(N)	Weight Before Wash	1436.2
	Loss On Wash (Q)	85.6	(O)	Weight After Wash	1350.6
(M)	Total - 200 (75 µm) Material (L + Q)	95.8	(Q)	Loss (N - O)	85.6
(S)	Total Aggregate in Sample For Gradation Calculations:		(Line (F) Above)		1436.2

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	99.97	100	
3/4 in (19 mm)		0.0	99.97	100	
1/2 in (12.5 mm)		0.0	99.97	100	100
3/8 in (9.5 mm)	8.7	0.6	99.37	99	90 - 100
No. 4 (4.75 mm)	397.0	27.6	71.77	72	90 Max
No. 8 (2.36 mm)	384.2	26.8	44.97	45	39 - 51
No. 16 (1.18µm)	236.8	16.5	28.47	28	
No. 30 (600 µm)	150.9	10.5	17.97	18	
No. 50 (300µm)	88.8	6.2	11.77	12	
No. 200 (75µm)	73.6	5.1	6.67	6.7	2.0 - 10.0
- 200 (75µm) (M)	95.8	6.67			
Total Wt. (W)	1435.8				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1350.2	0.03 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 29: Gradation of Aggregates from binder burn-off for All Skid Sample #1

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm All Skid # 2

Technician: Givens / Miller Sample #: 2 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538 °C	Data After Ignition	
(A)	Weight of Basket + Sample	4592.0	(D)	Weight of Basket + Aggregate
(B)	Weight of Basket	3060.6	(E)	Weight of Basket
(C)	Sample Weight (A - B)	1531.4	(F)	Aggregate Weight (D - E)
(K)	Percent Asphalt Check: $\{ [(C - F) / C] \times 100 - (\text{Calibration Factor}) \}$			6.1

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	7.8	(N)	Weight Before Wash	1437.0
	Loss On Wash (Q)	85.1	(O)	Weight After Wash	1351.9
(M)	Total - 200 (75 µm) Material (L + Q)	92.9	(Q)	Loss (N - O)	85.1
(S)	Total Aggregate in Sample For Gradation Calculations:			(Line (F) Above)	1437.0

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	99.86	100	
3/4 in (19 mm)		0.0	99.86	100	
1/2 in (12.5 mm)		0.0	99.86	100	100
3/8 in (9.5 mm)	22.0	1.5	98.36	98	90 - 100
No. 4 (4.75 mm)	406.8	28.3	70.06	70	90 Max
No. 8 (2.36 mm)	374.3	26.0	44.06	44	39 - 51
No. 16 (1.18µm)	231.9	16.1	27.96	28	
No. 30 (600 µm)	148.3	10.3	17.66	18	
No. 50 (300µm)	87.9	6.1	11.56	12	
No. 200 (75µm)	72.8	5.1	6.46	6.5	2.0 - 10.0
- 200 (75µm) (M)	92.9	6.46			
Total Wt. (W)	1436.9				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1351.8	0.01 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 30: Gradation of Aggregates from binder burn-off for All Skid Sample #2

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm Opposite Skid # 1

Technician: Givens / Miller Sample #: 5 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538°C	Data After Ignition	
(A)	Weight of Basket + Sample	4651.8	(D)	Weight of Basket + Aggregate 4553.8
(B)	Weight of Basket	3058.4	(E)	Weight of Basket 3058.4
(C)	Sample Weight (A - B)	1593.4	(F)	Aggregate Weight (D - E) 1495.4
(K)	Percent Asphalt Check: $\{ [(C - F) / C] \times 100 - (\text{Calibration Factor}) \}$			6.1

Minus 75 µm Material			Washed Grading	
(L)	Weight In Pan After Gradation	7.4	(N) Weight Before Wash	1495.4
	Loss On Wash (Q)	87.7	(O) Weight After Wash	1407.7
(M)	Total - 200 (75 µm) Material (L + Q)	95.1	(Q) Loss (N - O)	87.7
(S)	Total Aggregate in Sample For Gradation Calculations:		(Line (F) Above)	1495.4

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	99.95	100	
3/4 in (19 mm)		0.0	99.95	100	
1/2 in (12.5 mm)		0.0	99.95	100	100
3/8 in (9.5 mm)	13.6	0.9	99.05	99	90 - 100
No. 4 (4.75 mm)	441.8	29.5	69.55	70	90 Max
No. 8 (2.36 mm)	368.6	24.6	44.95	45	39 - 51
No. 16 (1.18µm)	255.2	17.1	27.85	28	
No. 30 (600 µm)	155.1	10.4	17.45	17	
No. 50 (300µm)	88.8	5.9	11.55	12	
No. 200 (75µm)	77.2	5.2	6.35	6.4	2.0 - 10.0
- 200 (75µm) (M)	95.1	6.35			
Total Wt. (W)	1495.4				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1407.7	0 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 31: Gradation of Aggregates from binder burn-off for Opposite Skid Sample #1

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm Opposite Skid # 2

Technician: Givens / Miller Sample #: 6 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538°C	Data After Ignition	
(A)	Weight of Basket + Sample	4711.2	(D)	Weight of Basket + Aggregate
(B)	Weight of Basket	3060.7	(E)	Weight of Basket
(C)	Sample Weight (A - B)	1650.5	(F)	Aggregate Weight (D - E)
(K)	Percent Asphalt Check: $\{ [(C - F) / C] \times 100 - (\text{Calibration Factor}) \}$			6.1

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	9.7	(N)	Weight Before Wash	1548.9
	Loss On Wash (Q)	90.2	(O)	Weight After Wash	1458.7
(M)	Total - 200 (75 µm) Material (L + Q)	99.9	(Q)	Loss (N - O)	90.2
(S)	Total Aggregate in Sample For Gradation Calculations:			(Line (F) Above)	1548.9

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	100.04	100	
3/4 in (19 mm)		0.0	100.04	100	
1/2 in (12.5 mm)		0.0	100.04	100	100
3/8 in (9.5 mm)	15.0	1.0	99.04	99	90 - 100
No. 4 (4.75 mm)	440.0	28.4	70.64	71	90 Max
No. 8 (2.36 mm)	390.2	25.2	45.44	45	39 - 51
No. 16 (1.18µm)	271.1	17.5	27.94	28	
No. 30 (600 µm)	160.0	10.3	17.64	18	
No. 50 (300µm)	92.9	6.0	11.64	12	
No. 200 (75µm)	80.2	5.2	6.44	6.4	2.0 - 10.0
- 200 (75µm) (M)	99.9	6.44			
Total Wt. (W)	1549.3				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1459.1	-0.03 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 32: Gradation of Aggregates from binder burn-off for Opposite Skid Sample #2

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm Per Design # 1

Technician: Givens / Miller Sample #: 7 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538 °C	Data After Ignition	
(A)	Weight of Basket + Sample	4636.3	(D)	Weight of Basket + Aggregate 4540.3
(B)	Weight of Basket	3058.4	(E)	Weight of Basket 3058.4
(C)	Sample Weight (A - B)	1577.9	(F)	Aggregate Weight (D - E) 1481.9
(K)	Percent Asphalt Check: $\{ [(C - F) / C] \times 100 - (\text{Calibration Factor}) \}$			6.0

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	5.0	(N)	Weight Before Wash	1481.9
	Loss On Wash (Q)	89.1	(O)	Weight After Wash	1392.8
(M)	Total - 200 (75 µm) Material (L + Q)	94.1	(Q)	Loss (N - O)	89.1
(S)	Total Aggregate in Sample For Gradation Calculations:			(Line (F) Above)	1481.9

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	99.94	100	
3/4 in (19 mm)		0.0	99.94	100	
1/2 in (12.5 mm)		0.0	99.94	100	100
3/8 in (9.5 mm)	21.2	1.4	98.54	99	90 - 100
No. 4 (4.75 mm)	418.5	28.2	70.34	70	90 Max
No. 8 (2.36 mm)	377.6	25.5	44.84	45	39 - 51
No. 16 (1.18µm)	252.7	17.1	27.74	28	
No. 30 (600 µm)	150.5	10.2	17.54	18	
No. 50 (300µm)	92.6	6.2	11.34	11	
No. 200 (75µm)	74.5	5.0	6.34	6.3	2.0 - 10.0
- 200 (75µm) (M)	94.1	6.34			
Total Wt. (W)	1481.7				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1392.6	0.01 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 33: Gradation of Aggregates from binder burn-off for Per Design Sample #1

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm Per Design # 2

Technician: Givens / Miller Sample #: 8 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538 °C	Data After Ignition		
(A)	Weight of Basket + Sample	4624.5	(D)	Weight of Basket + Aggregate	4527.6
(B)	Weight of Basket	3060.9	(E)	Weight of Basket	3060.9
(C)	Sample Weight (A - B)	1563.6	(F)	Aggregate Weight (D - E)	1466.7
(K)	Percent Asphalt Check: { [(C - F) / C] X 100 - (Calibration Factor) }				6.1

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	4.4	(N)	Weight Before Wash	1466.7
	Loss On Wash (Q)	88.3	(O)	Weight After Wash	1378.4
(M)	Total - 200 (75 µm) Material (L + Q)	92.7	(Q)	Loss (N - O)	88.3
(S)	Total Aggregate in Sample For Gradation Calculations:		(Line (F) Above)		1466.7

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	100.02	100	
3/4 in (19 mm)		0.0	100.02	100	
1/2 in (12.5 mm)		0.0	100.02	100	100
3/8 in (9.5 mm)	14.7	1.0	99.02	99	90 - 100
No. 4 (4.75 mm)	425.5	29.0	70.02	70	90 Max
No. 8 (2.36 mm)	366.7	25.0	45.02	45	39 - 51
No. 16 (1.18µm)	248.7	17.0	28.02	28	
No. 30 (600 µm)	152.9	10.4	17.62	18	
No. 50 (300µm)	92.4	6.3	11.32	11	
No. 200 (75µm)	73.5	5.0	6.32	6.3	2.0 - 10.0
- 200 (75µm) (M)	92.7	6.32			
Total Wt. (W)	1467.1				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1378.8	-0.03 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 34: Gradation of Aggregates from binder burn-off for Per Design Sample #2

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm No Skid # 1

Technician: Givens / Miller Sample #: 3 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538 °C	Data After Ignition	
(A)	Weight of Basket + Sample	4574.9	(D)	Weight of Basket + Aggregate 4479.3
(B)	Weight of Basket	3058.2	(E)	Weight of Basket 3058.2
(C)	Sample Weight (A - B)	1516.7	(F)	Aggregate Weight (D - E) 1421.1
(K)	Percent Asphalt Check: $\{ [(C - F) / C] \times 100 - (\text{Calibration Factor}) \}$			6.2

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	6.2	(N)	Weight Before Wash	1421.1
	Loss On Wash (Q)	87.1	(O)	Weight After Wash	1334.0
(M)	Total - 200 (75 µm) Material (L + Q)	93.3	(Q)	Loss (N - O)	87.1
(S)	Total Aggregate in Sample For Gradation Calculations:			(Line (F) Above)	1421.1

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	100.06	100	
3/4 in (19 mm)		0.0	100.06	100	
1/2 in (12.5 mm)		0.0	100.06	100	100
3/8 in (9.5 mm)	14.2	1.0	99.06	99	90 - 100
No. 4 (4.75 mm)	423.8	29.8	69.26	69	90 Max
No. 8 (2.36 mm)	339.0	23.9	45.36	45	39 - 51
No. 16 (1.18µm)	238.2	16.8	28.56	29	
No. 30 (600 µm)	150.3	10.6	17.96	18	
No. 50 (300µm)	91.5	6.4	11.56	12	
No. 200 (75µm)	70.7	5.0	6.56	6.6	2.0 - 10.0
- 200 (75µm) (M)	93.3	6.56			
Total Wt. (W)	1421.0				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1333.9	0.01 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 35: Gradation of Aggregates from binder burn-off for No Skid Sample #1

West Virginia Division of Highways
Asphalt Content By Ignition Method (AASHTO T308, Test Method A) And
Mechanical Analysis Of Extracted Aggregate - AASHTO T30

Material: 1420918 Size: 9.5mm No Skid # 2

Technician: Givens / Miller Sample #: 4 Calibration Factor: -0.09 Date: 2/27/2020

Data Before Ignition		Test Temp: 538 ^o C	Data After Ignition		
(A)	Weight of Basket + Sample	4569.5	(D)	Weight of Basket + Aggregate	4474.0
(B)	Weight of Basket	3060.5	(E)	Weight of Basket	3060.5
(C)	Sample Weight (A - B)	1509.0	(F)	Aggregate Weight (D - E)	1413.5
(K)	Percent Asphalt Check: { [(C - F) / C] X 100 - (Calibration Factor) }				6.2

Minus 75 µm Material			Washed Grading		
(L)	Weight In Pan After Gradation	6.1	(N)	Weight Before Wash	1413.5
	Loss On Wash (Q)	85.6	(O)	Weight After Wash	1327.9
(M)	Total - 200 (75 µm) Material (L + Q)	91.7	(Q)	Loss (N - O)	85.6
(S)	Total Aggregate in Sample For Gradation Calculations:			(Line (F) Above)	1413.5

Gradation Analysis					
Sieve Size	Weight Retained	Percent Retained	Percent Passing	Reported Percent Passing	Tolerance Limits
2 in (50 mm)					
1 1/2 in (37.5 mm)					
1 in (25mm)		0.0	99.98	100	
3/4 in (19 mm)		0.0	99.98	100	
1/2 in (12.5 mm)		0.0	99.98	100	100
3/8 in (9.5 mm)	19.8	1.4	98.58	99	90 - 100
No. 4 (4.75 mm)	414.5	29.3	69.28	69	90 Max
No. 8 (2.36 mm)	342.4	24.2	45.08	45	39 - 51
No. 16 (1.18µm)	239.5	16.9	28.18	28	
No. 30 (600 µm)	146.3	10.4	17.78	18	
No. 50 (300µm)	90.2	6.4	11.38	11	
No. 200 (75µm)	69.1	4.9	6.48	6.5	2.0 - 10.0
- 200 (75µm) (M)	91.7	6.48			
Total Wt. (W)	1413.5				

0.2% Check:	W - Q	100 (O - X) / O
= Total Weight (X)	1327.9	0 %

Attach all asphalt content oven printouts to this report.

The Summation Of The Retained Weights Of All Of The Sieves Plus The Pan Weight Must Check The Dry Weight After Wash (O) Within 0.2% Of The Total Weight (X).

Figure 36: Gradation of Aggregates from binder burn-off for No Skid Sample #2

Insoluble Residue per WVDOH Method

Table 25: IR Data for WVDOH Method All Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.9	100%	0.90	0.00
Location:		+50	0.9	98%	0.88	0.02
Sample Type:		+100	2.7	30%	0.81	1.89
Sample Wt., g:	203.3	+200	24.2	3%	0.73	23.47
Insoluble Residue Wt., g:	32.3	-200	3.5	N/A	+200 Qtz.,g:	25.39
Sieving Loss/Gain, %:	0.3	Total:	32.2		+200 Qtz.,%:	12

Table 26: IR Data for WVDOH Method All Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.9	99%	0.89	0.01
Location:		+50	1.1	99%	1.09	0.01
Sample Type:		+100	1.9	30%	0.57	1.33
Sample Wt., g:	202.1	+200	24.7	5%	1.24	23.47
Insoluble Residue Wt., g:	33.1	-200	4.2	N/A	+200 Qtz.,g:	24.82
Sieving Loss/Gain, %:	0.9	Total:	32.8		+200 Qtz.,%:	12

Table 27: IR Data for WVDOH Method Opposite Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	1.2	100%	1.19	0.01
Location:		+50	2.8	99%	2.77	0.03
Sample Type:		+100	4.6	85%	3.91	0.69
Sample Wt., g:	208.1	+200	14	55%	7.70	6.30
Insoluble Residue Wt., g:	37	-200	14.2	N/A	+200 Qtz.,g:	7.02
Sieving Loss/Gain, %:	0.5	Total:	36.8		+200 Qtz.,%:	3

Table 28: IR Data for WVDOH Method Opposite Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	3.3	100%	3.28	0.02
Location:		+50	4.3	93%	4.00	0.30
Sample Type:		+100	3.6	80%	2.88	0.72
Sample Wt., g:	206.5	+200	11.4	50%	5.70	5.70
Insoluble Residue Wt., g:	36.1	-200	13.3	N/A	+200 Qtz.,g:	6.74
Sieving Loss/Gain, %:	0.6	Total:	35.9		+200 Qtz.,%:	3

Table 29: IR Data for WVDOH Method Per Design Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.8	100%	0.80	0.00
Location:		+50	1.1	100%	1.09	0.01
Sample Type:		+100	2.1	15%	0.32	1.79
Sample Wt., g:	204.9	+200	21.6	3%	0.65	20.95
Insoluble Residue Wt., g:	30.9	-200	5.2	N/A	+200 Qtz.,g:	22.75
Sieving Loss/Gain, %:	0.3	Total:	30.8		+200 Qtz.,%:	11

Table 30: IR Data for WVDOH Method Per Design Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	1	100%	1.00	0.01
Location:		+50	1.3	99%	1.29	0.01
Sample Type:		+100	2.2	20%	0.44	1.76
Sample Wt., g:	206.6	+200	22	2%	0.44	21.56
Insoluble Residue Wt., g:	32.2	-200	5.3	N/A	+200 Qtz.,g:	23.34
Sieving Loss/Gain, %:	1.2	Total:	31.8		+200 Qtz.,%:	11

Table 31: IR Data for WVDOH Method No Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	2.3	100%	2.29	0.01
Location:		+50	3.6	100%	3.58	0.02
Sample Type:		+100	4.6	95%	4.37	0.23
Sample Wt., g:	205.1	+200	10.3	75%	7.73	2.58
Insoluble Residue Wt., g:	36	-200	15	N/A	+200 Qtz.,g:	2.83
Sieving Loss/Gain, %:	0.6	Total:	35.8		+200 Qtz.,%:	1

Table 32: IR Data for WVDOH Method No Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	1.8	100%	1.79	0.01
Location:		+50	3.1	99%	3.07	0.03
Sample Type:		+100	4.4	93%	4.09	0.31
Sample Wt., g:	207.8	+200	11.2	80%	8.96	2.24
Insoluble Residue Wt., g:	36.2	-200	15.4	N/A	+200 Qtz.,g:	2.59
Sieving Loss/Gain, %:	0.8	Total:	35.9		+200 Qtz.,%:	1

Insoluble Residue per Material Passing WVDOH Method

Table 33: IR Data for Material Passing WVDOH Method All Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	0.9	75%	0.68	0.23
Sample Type:		+100	4.8	7%	0.34	4.46
Sample Wt., g:	204.7	+200	43.7	2%	0.87	42.83
Insoluble Residue Wt., g:	51	-200	1.7	N/A	+200 Qtz.,g:	47.52
Sieving Loss/Gain, %:	-0.2	Total:	51.1		+200 Qtz.,%:	23

Table 34: IR Data for Material Passing WVDOH Method All Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	0.8	80%	0.64	0.16
Sample Type:		+100	5.1	7%	0.36	4.74
Sample Wt., g:	210.6	+200	47.7	1%	0.48	47.22
Insoluble Residue Wt., g:	55.9	-200	2.2	N/A	+200 Qtz.,g:	52.13
Sieving Loss/Gain, %:	0.2	Total:	55.8		+200 Qtz.,%:	25

Table 35: IR Data for Material Passing WVDOH Method Opposite Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	2.2	98%	2.16	0.04
Sample Type:		+100	4.7	50%	2.35	2.35
Sample Wt., g:	207.1	+200	19.4	15%	2.91	16.49
Insoluble Residue Wt., g:	36.2	-200	9.8	N/A	+200 Qtz.,g:	18.88
Sieving Loss/Gain, %:	0.3	Total:	36.1		+200 Qtz.,%:	9

Table 36: IR Data for Material Passing WVDOH Method Opposite Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	1.1	97%	1.07	0.03
Sample Type:		+100	4.5	50%	2.25	2.25
Sample Wt., g:	206.2	+200	21.1	20%	4.22	16.88
Insoluble Residue Wt., g:	38.9	-200	12	N/A	+200 Qtz.,g:	19.16
Sieving Loss/Gain, %:	0.5	Total:	38.7		+200 Qtz.,%:	9

Table 37: IR Data for Material Passing WVDOH Method Per Design Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	0.8	93%	0.74	0.06
Sample Type:		+100	5.1	7%	0.36	4.74
Sample Wt., g:	208.5	+200	40.3	1%	0.40	39.90
Insoluble Residue Wt., g:	48.4	-200	2.3	N/A	+200 Qtz.,g:	44.70
Sieving Loss/Gain, %:	-0.2	Total:	48.5		+200 Qtz.,%:	21

Table 38: IR Data for Material Passing WVDOH Method Per Design Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	0.6	95%	0.57	0.03
Sample Type:		+100	4.7	10%	0.47	4.23
Sample Wt., g:	207.5	+200	41.1	1%	0.41	40.69
Insoluble Residue Wt., g:	49.5	-200	2.9	N/A	+200 Qtz.,g:	44.95
Sieving Loss/Gain, %:	0.4	Total:	49.3		+200 Qtz.,%:	22

Table 39: IR Data for Material Passing WVDOH Method No Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	1.1	97%	1.07	0.03
Sample Type:		+100	4.3	60%	2.58	1.72
Sample Wt., g:	208.6	+200	14.8	30%	4.44	10.36
Insoluble Residue Wt., g:	32.8	-200	12.5	N/A	+200 Qtz.,g:	12.11
Sieving Loss/Gain, %:	0.3	Total:	32.7		+200 Qtz.,%:	6

Table 40: IR Data for Material Passing WVDOH Method No Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	-	-	-	-
Location:		+50	1.5	99%	1.49	0.02
Sample Type:		+100	4.9	70%	3.43	1.47
Sample Wt., g:	205.1	+200	15.1	40%	6.04	9.06
Insoluble Residue Wt., g:	33.9	-200	12.2	N/A	+200 Qtz.,g:	10.55
Sieving Loss/Gain, %:	0.6	Total:	33.7		+200 Qtz.,%:	5

Insoluble Residue per Total Blend of Sample

Table 41: IR Data for Total Blend All Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	1.1	100%	1.09	0.01
Location:		+50	1.1	97%	1.07	0.03
Sample Type:		+100	3.5	5%	0.18	3.33
Sample Wt., g:	205.2	+200	27.6	1%	0.28	27.32
Insoluble Residue Wt., g:	36.5	-200	3.3	N/A	+200 Qtz.,g:	30.69
Sieving Loss/Gain, %:	-0.3	Total:	36.6		+200 Qtz.,%:	15

Table 42: IR Data for Total Blend All Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.2	100%	0.20	0.00
Location:		+50	0.7	97%	0.68	0.02
Sample Type:		+100	4.6	3%	0.14	4.46
Sample Wt., g:	220.4	+200	42	1%	0.42	41.58
Insoluble Residue Wt., g:	52.4	-200	4.7	N/A	+200 Qtz.,g:	46.06
Sieving Loss/Gain, %:	0.4	Total:	52.2		+200 Qtz.,%:	21

Table 43: IR Data for Total Blend Opposite Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.3	99%	0.30	0.00
Location:		+50	1.2	97%	1.16	0.04
Sample Type:		+100	3.5	40%	1.40	2.10
Sample Wt., g:	202.5	+200	24.1	10%	2.41	21.69
Insoluble Residue Wt., g:	38.5	-200	9.3	N/A	+200 Qtz.,g:	23.83
Sieving Loss/Gain, %:	0.3	Total:	38.4		+200 Qtz.,%:	12

Table 44: IR Data for Total Blend Opposite Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.6	99%	0.59	0.01
Location:		+50	1.8	97%	1.75	0.05
Sample Type:		+100	3.8	40%	1.52	2.28
Sample Wt., g:	202	+200	20.4	10%	2.04	18.36
Insoluble Residue Wt., g:	37.1	-200	10.4	N/A	+200 Qtz.,g:	20.70
Sieving Loss/Gain, %:	0.3	Total:	37		+200 Qtz.,%:	10

Table 45: IR Data for Total Blend Per Design Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.2	99%	0.20	0.00
Location:		+50	1	95%	0.95	0.05
Sample Type:		+100	4.1	15%	0.62	3.49
Sample Wt., g:	209.7	+200	26.6	5%	1.33	25.27
Insoluble Residue Wt., g:	41.3	-200	9.2	N/A	+200 Qtz.,g:	28.81
Sieving Loss/Gain, %:	0.5	Total:	41.1		+200 Qtz.,%:	14

Table 46: IR Data for Total Blend Per Design Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	0.4	99%	0.40	0.00
Location:		+50	1.5	97%	1.46	0.04
Sample Type:		+100	3.6	15%	0.54	3.06
Sample Wt., g:	203.5	+200	23.1	5%	1.16	21.95
Insoluble Residue Wt., g:	38.8	-200	9.8	N/A	+200 Qtz.,g:	25.05
Sieving Loss/Gain, %:	1.0	Total:	38.4		+200 Qtz.,%:	12

Table 47: IR Data for Total Blend No Skid Sample #1

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	3.7	99%	3.66	0.04
Location:		+50	5.4	99%	5.35	0.05
Sample Type:		+100	3.4	70%	2.38	1.02
Sample Wt., g:	204	+200	12.3	40%	4.92	7.38
Insoluble Residue Wt., g:	38.5	-200	13	N/A	+200 Qtz.,g:	8.49
Sieving Loss/Gain, %:	1.8	Total:	37.8		+200 Qtz.,%:	4

Table 48: IR Data for Total Blend No Skid Sample #2

Sampled:		Size Mesh	Weight	Non-Quartz		Quartz
Test Run:			g	Vol %	g	g
Source:		+30	3.6	100%	3.58	0.02
Location:		+50	4.5	99%	4.46	0.04
Sample Type:		+100	3.8	60%	2.28	1.52
Sample Wt., g:	201.5	+200	17.7	20%	3.54	14.16
Insoluble Residue Wt., g:	40.8	-200	10.9	N/A	+200 Qtz.,g:	15.74
Sieving Loss/Gain, %:	0.7	Total:	40.5		+200 Qtz.,%:	8